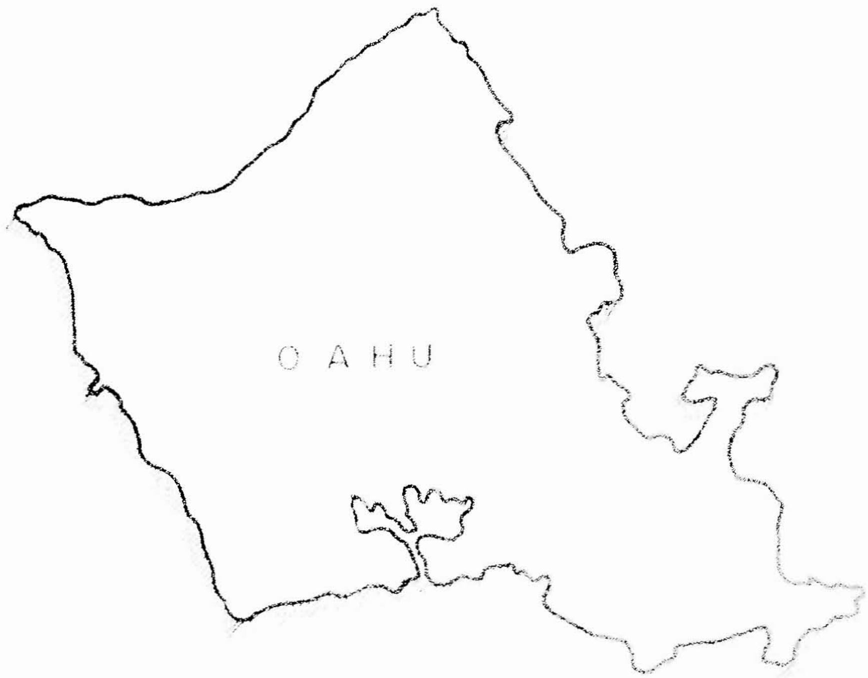
CLEAN WATER

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
PACIFIC SOUTHWEST REGION

REPORT ON POLLUTION OF THE NAVIGABLE WATERS OF PEARL HARBOR



U. S. DEPARTMENT OF THE INTERIOR

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U.S FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
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OCTOBER 1969

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SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

Pearl Harbor, one of the finest natural harbors in the Pacific Basin, encompasses over 9 square miles of surface area consisting of three lochs. The State of Hawaii has established water quality standards to protect and enhance this valuable water resource.

Present use of Pearl Harbor is restricted to defense purposes, with limited access permitted for commercial bait fishing and sightseeing. Urban encroachment upon the harbor is increasing. The farm lands once surrounding Pearl Harbor have now become housing tracts. Agencies are carefully examining the limited use being made of the harbor and determining possible future uses by the public.

At present, untreated sewage flows into Pearl Harbor. Federal, municipal, and industrial agencies are responsible for these flows.

At the request of the State of Hawaii, the Federal Water Pollution Control Administration (FWPCA) documented the sources of pollution in Pearl Harbor and identified their effects upon its water quality and shellfish resources.

CONCLUSIONS

1. Untreated wastes are entering Pearl Harbor from Federal, municipal, and industrial sources. These waste discharges are adversely affecting the natural resources in the harbor and jeopardizing the existence of oysters in West Loch.

2. The pollution in Pearl Harbor results primarily from the following major waste discharges and activities:

Domestic Wastes

a) Navy South Avenue outfall discharging 3.5 million gallons per day (mgd) of raw sewage into the main Pearl Harbor channel.
b) Halawa Sewage Treatment Plant outfall discharging 0.5 mgd of effluent after primary treatment into East Loch.
c) Aiea outfall discharging 0.5 mgd of raw sewage into East Loch.
d) Pearl City Sewage Treatment Plant discharging 2.6 mgd of effluent after primary treatment into Middle Loch.
e) Waipahu ditch discharging 2 mgd of raw sewage and 2 mgd of sugar mill wastes into West Loch.

Industrial Wastes

a) Primo Brewery
b) Pearl Harbor Naval Shipyard
c) Hawaiian Electric Company
d) Two Navy power plants
e) Oahu Sugar Company

3. Coliform bacterial contamination of oysters in West Loch is due to the discharge of untreated domestic wastes. When its waste water is not used by the Oahu Sugar Company for irrigation, the town of Waipahu becomes a major source of these wastes. Salmonella, a disease-producing pathogenic bacteria, was identified in oysters taken from one West Loch oyster bed. The presence of Salmonella organisms in oysters and in the overlying water is hazardous to the health of persons who come in contact with the water or ingest the oysters.

4. Sediments and debris are smothering the oysters. The heavy loads of settleable and suspended solids (10,000 tons/yr.) being discharged into West Loch have reduced the size of certain major oyster beds by more than 50 percent during the past 7 years.

5. The aesthetics of Pearl Harbor are being degraded by debris, originating primarily from an open dump, which floats and litters the shoreline and settles into the oyster beds in West Loch. Oil slicks are also common in East Loch and the harbor entrance channel.

6. Bacterial and nutrient levels at numerous locations throughout the harbor exceed those permitted by established water quality standards. Tributaries entering Pearl Harbor also contain coliform concentrations in excess of standards.

7. If Pearl Harbor was officially open to the public, activities such as fishing, swimming, and collecting shellfish would be hazardous to public health because of the high degree of bacterial contamination.

RECOMMENDATIONS

1. Waste flows from the Waipahu sewerage system and Oahu Sugar Company should immediately be prevented from entering the Class AA zoned waters in West Loch or waters in the vicinity of any existing oyster beds. These flows can be used for irrigation, ponded, or temporarily diverted to Middle Loch until suitable handling or treatment is provided.

2. Further encroachment into the Pearl Harbor estuary by the city and county of Honolulu dump in West Loch should immediately cease. Disposal of future incinerator wastes into Pearl Harbor should not be permitted.

3. Sources of the high nutrient loads in the Waikele and Waiawa Streams should be identified and appropriate action taken to minimize pollution from these sources.

4. Further study should be undertaken to ensure that the oyster resource is not contaminated by water-borne pesticides. The FWPCA survey did not investigate hazards related to the use of pesticides, or the handling, mixing, and applying of toxic wastes.

II

INTRODUCTION

STATEMENT OF PROBLEM

Prior to World War II, uses of the waters of Pearl Harbor included yachting, fishing, swimming, and collecting shellfish. Progressive pollution since then has caused the harbor to be placed "off limits" to all such activities.

Because of security reasons and reported pollution, the waters of Pearl Harbor have been closed to the public by the U. S. Navy since the conclusion of World War II. Population in the watershed draining to Pearl Harbor has dramatically increased since then. Water quality has deteriorated over the years despite certain waste discharges being stopped or diverted for treatment prior to disposal. In 1968, following the establishment of water quality standards for the State of Hawaii, Pearl Harbor was designated as the highest priority pollution problem in the State.

Past engineering and biological studies conducted on Pearl Harbor did not examine the sources of pollution or evaluate their effect upon the waters and shellfish resources. The combined deterioration of the once pristine waters and shellfish resources in Pearl Harbor prompted the State of Hawaii to request technical assistance from the Federal Water Pollution Control Administration.

AUTHORITY

The Pacific Islands Basin Office of the Southwest Region, Federal Water Pollution Control Administration, was requested by the Hawaii State Health Department, in a letter dated September 26, 1968, to provide technical assistance on the pollution problems affecting Pearl Harbor. The letter stated: "We believe that the situation existing in Pearl Harbor is one of the more (if not the most) complex problems facing us in our collective effort to control water pollution in Hawaii."

Authority for this survey is provided under the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 a et seq.). Section 5 (b) of this act authorizes the

Secretary, "...upon request of any State water pollution agency...(to) conduct investigations and research, and make surveys concerning any specific problems of water pollution."

OBJECTIVES AND SCOPE

Based upon the above request, the FWPCA established the following objectives:

1) To extrapolate and summarize all existing information on the water quality of Pearl Harbor through review of all available literature.
2) To determine the quantity and principal characteristics of the major discharges entering Pearl Harbor.
3) To determine the effects of the major discharges on the receiving water quality and on the organisms, including benthic life.
4) To develop information leading to the determination of the overall quality of the harbor water.

The Federal Water Pollution Control Administration initiated the Pearl Harbor survey in January 1969. The study was carried out over a period of 6 months, and maximum use was made of existing reports and known sources of information. Major emphasis was placed upon determining sources contaminating the oysters in West Loch, the prime oyster-growing area in the State.

All laboratory work was performed in accordance with procedures described in Standard Methods (APHA, 1965).

Detailed information on the organization of the survey appears in appendix A of this report.

ACKNOWLEDGEMENTS

Assistance and cooperation from the following organizations helped to make this study possible:

Department of Defense, U. S. Navy

Department of the Interior, U. S. Geological Survey
State of Hawaii, Health Department
State of Hawaii, Division of Fish and Game
City and County of Honolulu, Division of Sewers
Oahu Sugar Company

Special recognition is given to the Fleet Air Photographic Laboratory, U. S. Navy, for the aerial photographs of West Loch and to MIDPAC OICC, U. S. Navy, for use of their skiff during preliminary surveys of Pearl Harbor.

III

BACKGROUND

HISTORY OF AREA

Pearl Harbor was known to the ancient Hawaiians as "Puuloa" and was believed to be the home of the shark goddess "Kaahupahua." A fishing shrine was located on the shores of the harbor, and walled fishtraps were known to be operative in its waters until the late 1890's. The U. S. Navy acquired rights to the harbor from the Hawaiian kingdom in 1873. Work to clear the harbor channel and construction of docking facilities were not begun until 1898, when the Spanish-American War positively proved the need for such a naval facility.

Today, Pearl Harbor is the headquarters of the U. S. Pacific Fleet. With 425 ships, 3,000 aircraft, and 240,000 men, it is the largest naval command in the world, and the naval shipyard located there is the largest military installation of its kind outside the continental United States. During 1968, the Navy contributed more than $285 million to the economy of the State of Hawaii. This represented nearly one-third of the total Federal expenditures in the State.

WATER USES

Very little documented literature now remains concerning the early history of Pearl Harbor. References have been made to pearl oysters, saltworks, fish ponds, and rice and taro fields. The degree to which the harbor was used for these purposes, however, is uncertain.

Today, the waters of Pearl Harbor are under the control of the U. S. Navy and their major use is restricted to military activities. Neither swimming nor commercial fishing are permitted in the harbor. Permits issued by the Navy, however, allow moderate public sport fishing and boating in some areas. Several Waikiki excursion boats visit the harbor daily for sight-seeing purposes, and the Navy also operates its own excursion boats to the Arizona War Memorial on Ford Island. The local bait fish for tuna fishery is the Nehu, and the Navy permits fishing for this species in the harbor. At present, it is a popular practice to use the harbor for shoreline fishing and crabbing.

CLIMATE

Oahu basks in the warm sunshine much of the year. Fanned from the northeast by prevailing tropical tradewinds, the island's temperature varies from a high of about 85 degrees to a low of 60 degrees with an average daily span of 9 degrees. Normal relative humidity is 70 percent, except during occasional "kona" weather.

Elevation and geographic location have a significant effect on rainfall. The average annual rainfall at the town of Waipahu, elevation 59 feet above sea level, is approximately 30 inches. At the Waiawa station, elevation 725 feet above sea level, the yearly average is about 160 inches. Such variations are generally true throughout the islands.

PHYSICAL CHARACTERISTICS OF PEARL HARBOR

Pearl Harbor is a 9-square-mile estuary made up of three embayments or lochs. These lochs (East, Middle, and West Loch) are drowned river valleys which have been modified by wave and current action. The upper reaches of the lochs are generally quite shallow (5 to 10 feet) while the lower reaches have been dredged and at some places exceed 50 feet in depth. A quarter-mile-wide entrance channel connects the inner harbor to the sea. There are five streams which drain into Pearl Harbor; near each stream is an onshore spring. Mean flow estimates made in past surveys put the combined stream discharges at 56 mgd and the mean flow of spring discharges at 87 mgd.

WATER QUALITY STANDARDS

The Federal Water Pollution Control Act, as amended, provides for the establishment of water quality standards. It has been the position of the U. S. Department of the Interior through its Federal Water Pollution Control Administration to encourage and support the States in establishing their own standards. As provided in the Federal act, standards adopted by a State may be accepted by the Secretary of the Interior if he determines that the State criteria and implementation plan are consistent with the purposes of the act, i.e., "... to enhance the quality and value of our water resources and to establish a national policy for the prevention, control, and abatement of water pollution."

Following a series of public hearings, Hawaii adopted water quality standards on December 26, 1967. These standards were submitted to the Secretary of the Interior in accordance with the Federal act and were approved by the Secretary, with certain exceptions, on March 13, 1968. Appendix B of this report contains "Public Health Regulations, Department of Health, State of Hawaii, Water Quality Standards, Chapter 37-A."

The following is a summary of the water quality standards applicable to Pearl Harbor:

The water quality standards adopted by the State of Hawaii divide Pearl Harbor into three classes of water uses (Public Health Regulations, ch. 37-A, sec. 3 & 5).

Class AA waters in West Loch (figure A1, appendix A) protect the following uses: "...oceanographic research, propagation of shellfish and marine life, conservation of coral reefs and wilderness areas, and aesthetic enjoyment. It is the objective of this class of waters that they remain in as nearly their natural, pristine state as possible, with an absolute minimum of pollution from any source." Accordingly, "no zones of mixing will be permitted in these waters."

Uses protected in Class A waters are: "...recreational, including fishing, swimming, bathing, and other water-contact sports, and aesthetic enjoyment." These waters are to be kept free of trash, solid materials, or oils and cannot receive any waste effluent unless it has received the best practicable treatment or control compatible with Class A standards.

Uses protected in Class B waters include: "...small boat harbors, commercial, shipping and industrial, bait fishing, and aesthetic enjoyment." Discharge of pollutants is to be controlled to the maximum degree possible, and effluents are to receive the best practicable treatment or control to meet standards for this class. The Class B designation applies only to a limited area next to boat-docking facilities in bays and harbors. The rest of the waters in the bay or harbor are considered to be Class A unless otherwise designated.

The extent of the "limited" area around boat-docking facilities is not spelled out, so the delineation between Class B waters and Class A waters is arbitrary. For this study, sampling was carried out approximately 50 feet from all piers and shore lines and arbitrarily considered to be in Class A waters.

Two classifications have been established for fresh waters in the State of Hawaii. Class 1, which protects waters for drinking and food processing, does not pertain to streams entering Pearl Harbor. Uses protected in Class 2 streams include: "...bathing, swimming, recreation, growth and propagation of fish and other aquatic life, and agriculture and industrial water supply." These waters are to be kept clear of trash, solid materials, or oils and are not to serve as receiving waters for any effluent that has not received the best practicable treatment compatible with the class standards.

Basic water quality standards applicable to all waters in Hawaii are as follows: "All waters shall be free of substances attributable to discharges or wastes as follows:

1. Materials that will settle to form objectionable deposits.
2. Floating debris, oil, scum, and other matter.
3. Substances producing objectionable color, odor, taste, or turbidity.
4. Materials, including radionuclides, in concentrations or combinations which are toxic or which produce undesirable physiological responses in human, fish, and other animal life and plants.
5. Substances and conditions or combinations thereof in concentrations which produce undesirable aquatic life.

All waters shall also be free from soil particles resulting from erosion on land involved in earthwork, such as the construction of public works, highways, subdivisions, recreational, commercial, or industrial developments, or the cultivation and management of agricultural lands."

Specific standards applicable to particular water uses are also established. Below are listed those to which data in this report should be applied:

Parameter	Classes AA	A	B	2
1. Microbiological				
a. Total Coliforms bacteria (Organisms/100 ml)				
Median (not to exceed)	70	1,000	-	1,000
Upper decile maximum	230	2,400	-	2,400
b. Fecal Coliforms (Organisms/100 ml)				
30-day arithmetic mean (not to exceed)	-	200	400	200
Upper decile (not to exceed	-	400	1,000	400
2. pH				
a. Departure from natural	0.5	0.5	0.5	-
b. Maximum except from natural casuse	8.5	8.5	8.5	8.5
c. Minimum except from natural causes	8.0	7.0	7,0	6.5
3. Nutrients (mg/l)				
a. Total P. (not to exceed)	0.020	0.025	0.030	-
b. Total N. (not to exceed)	0.10	0.15	0.20	-
4. Dissolved Oxygen (mg/l)				
(not less than)	6.0	5.0	4.5	5.0
5. Temperature (F.) Departure from natural (not to exceed	1.5	1.5	1.5	-

IV

WASTE DISCHARGES

GENERAL

Both sewage and industrial wastes contain a variety of obnoxious constituents that can damage water quality and restrict its use. Oxygen-demanding materials can limit or destroy fish, fish food organisms, and other desirable aquatic life by removing dissolved oxygen from the waters. Greasy substances can form objectionable surface scums; settleable solids can create sludge deposits; and suspended materials can make once attractive waters appear turbid and discolored.

Industrial wastes may also contain additional objectionable chemicals and toxic substances that can kill aquatic life, taint fish flesh, or promote slime growths in the receiving waters. Heat from steam-electric generating plants can magnify the adverse effects of other decomposing wastes and, if excessive, can injure or kill fish and aquatic life.

Sewage contains large numbers of human intestinal bacteria. Some of these bacteria may be pathogens which can reinfect man. The coliform bacteria content of raw and treated sewage indicates the density of sewage-associated bacteria, which may include disease-producing pathogens.

The type and capacity of a sewage treatment plant and the skill of its operators determine the amount of pollutional constituents that can be removed from sewage. These types of sewage treatment plants are primary or secondary, with or without chlorination.

Primary treatment plants, which consist essentially of settling tanks and sludge digesters, can remove most of the scums and settleable solids, about one-third of the oxygen-demanding BOD (biological oxygen demand), and approximately 50 percent of the bacteria. Secondary treatment plants consist of primary units as well as secondary biological treatment units such as trickling filters, activated sludge, or oxidation lagoons. Such plants can remove about 80 to 95 percent of the BOD and coliform bacteria. Chlorination facilities for effective disinfection of properly treated sewage plant effluents can destroy more than 99.9 percent of the remaining sewage bacteria. To accomplish these reductions, however, treatment facilities must be properly designed, adequately sized, and skillfully operated.

INDUSTRIAL WASTES

The largest industrial waste loads entering Pearl Harbor are generated by Primo Brewery, Pearl Harbor Naval Shipyard, Hawaiian Electric Company, two Navy power plants, and Oahu Sugar Company. Wastes from the brewery and shipyard are discharged into domestic sewers before disposal into the harbor. Both the Hawaiian Electric Company and Navy power plants utilize harbor waters for cooling and return the heated water directly to the harbor. Sugar cane processing wastes from Oahu Sugar Company, consisting primarily of canewash water, are handled in one of three ways: (1) they are used to irrigate cane lands; (2) they are combined with raw sewage from Waipahu and used for irrigation; or (3) they are combined with raw sewage and discharged directly into West Loch. The latter method appeared to be the most frequent means of disposal during the survey. Approximately 2 to 2.5 mgd of sugar mill wastes are produced during the 8 or 9-month harvesting season.

Hawaiian Electric Company at Waiau uses both fresh water and water from Pearl Harbor for cooling. Approximately 10 mgd of fresh water and between 128,000 and 336,000 gallons per minute (gpm) of harbor water are utilized. Discharge temperatures range up to +10 degrees Fahrenheit (F.) above intake temperatures. Two Navy power plants discharge an average 36,000 gpm with a maximum 72,000 gpm thermal discharge into Pearl Harbor. At the time of this study, however, no data were available regarding discharge temperatures.

Separate characterization of industrial wastes was not attempted in the study because of the combining of industrial wastes with sewage. Results of the analysis of the combined discharges will be found in the following section.

DOMESTIC WASTES

Five major sewage discharges surveyed during this study include:

1) Navy South Avenue outfall discharging 3.5 mgd of raw sewage into Main Pearl Harbor Channel.
2) Halawa Sewage Treatment Plant outfall discharging 0.5 mgd of primary effluent into East Loch.
3) Aiea outfall discharging 0.5 mgd or raw sewage into East Loch.
4) Pearl City Sewage Treatment Plant discharging 2.6 mgd of primary effluent into Middle Loch.
5) Waipahu ditch discharging 2 mgd of raw sewage and 2 mgd of sugar mill wastes into West Loch. (Sampling points for these outfalls can be found by referring to table I and figure A1.)

The average discharge from all of the above sources amounted to 9.1 mdg for the months of March, April, and May 1969. Flows for the Navy's South Avenue outfall and the Aiea outfall were calculated on the basis of known populations. Other flows were taken from city and county of Honolulu records.

DISCUSSION OF DOMESTIC WASTE SURVEY

Phosphorus and nitrogen values were highest from the Halawa Sewage Treatment Plant outfall and lowest from the combined Waipahu sewage. The Halawa sewage Treatment Plant showed the lowest coliform concentration, and the Navy's outfall had the lowest solids content. These data are summarized in table I.

The very high solids from the Waipahu ditch reflect the influence of cane wash water combined with sewage. Cane wash water would also add to the coliform loads of the waste in Waipahu ditch.

Daily waste-load projections were computed for the five outfalls studied. These projections were calculated from mean daily flows and a summary of the results is presented in table II. As would be expected, the Waipahu outfall, when discharging sewage and sugar mill waste mixtures,

TABLE I

SEWAGE ANALYSES

AVERAGES OF THREE 24-HOUR COMPOSITE SAMPLES

STATION LOCATION (FIGURE A1)	STATION DESCRIPTION	TYPE OF DISCHARGE	SAMPLE DATES	PHOSPHORUS (MG/l)	NITROGEN (MG/l)	TOTAL SOLIDS SUSP. (MG/l)	TOTAL SOLIDS SETTLE. (MG/l)	COLIFORMS (ORG/100 ML) TOTAL	COLIFORMS (ORG/100 ML) FECAL
SE 08	Navy So. Ave. Manhole	Raw Sewage	May 21,22,23 1969	7.1	18.6	39.1	19.1	54.0 Millions	10.1 Millions
SE 06	Halawa STP Chlorine Contact Chamber	Primary Effluent	May 21,22,23 1969	11.2	20.1	95.4	23.9	*None detected	
SE 10	Aiea Manhole	Raw Sewage	May 26,27,28 1969	8.1	19.0	134.0	78.0	52.0 Millions	12.3 Millions
SE 07	Pearl City STP Chlorine Contact Chamber	Primary Effluent	May 21,22,23 1969	8.6	18.4	107.9	22.8	**29,500	430
SE 09	***Waipahu Ditch	Raw Sewage	May 26,27,28 1969	5.8	10.2	828.0	595.0	108.5 Millions	18.3 Millions

* Effluent appeared to be over-chlorinated.

** Chlorinator may not have been working.

*** Irrigation water mixed with raw sewage during sampling period.

TABLE II

PROJECTION OF DAILY WASTE LOADING

FROM SELECTED DISCHARGES IN PEARL HARBOR

AREA OF DISCHARGE	SOURCE OF WASTE	VOLUME (MGD)	PHOSPHORUS (LBS/DAY)	TOTAL NITROGEN (LBS/DAY)	SOLIDS (LBS/DAY) SUSPENDED	SETTLEABLE
Main Channel	Navy So. Ave. Sewer	3.5	207	543	1,141	558
Halawa Stream	Halawa STP	0.5	47	84	398	416
Aiea Bay	Aiea Sewer	0.5	34	79	559	325
Middle Loch	Pearl City STP	2.6	186	399	2,339	494
West Loch	*Waipahu Ditch	4.0	194	340	27,639	19,861
TOTALS		11.1	668	1,445	32,076	21,654

*Includes 2 mgd sugar mill wastes.

introduces a heavy solids load each day into West Loch. These daily solids values total 47,500 pounds, about 70 percent of which are settleable.

DIFFUSE SOURCES OF WASTE

Small scattered sources of waste discharging into Pearl Harbor were not studied. These are comprised of wastes from Navy ships, storm drains, and numerous small individual raw sewage outfalls.

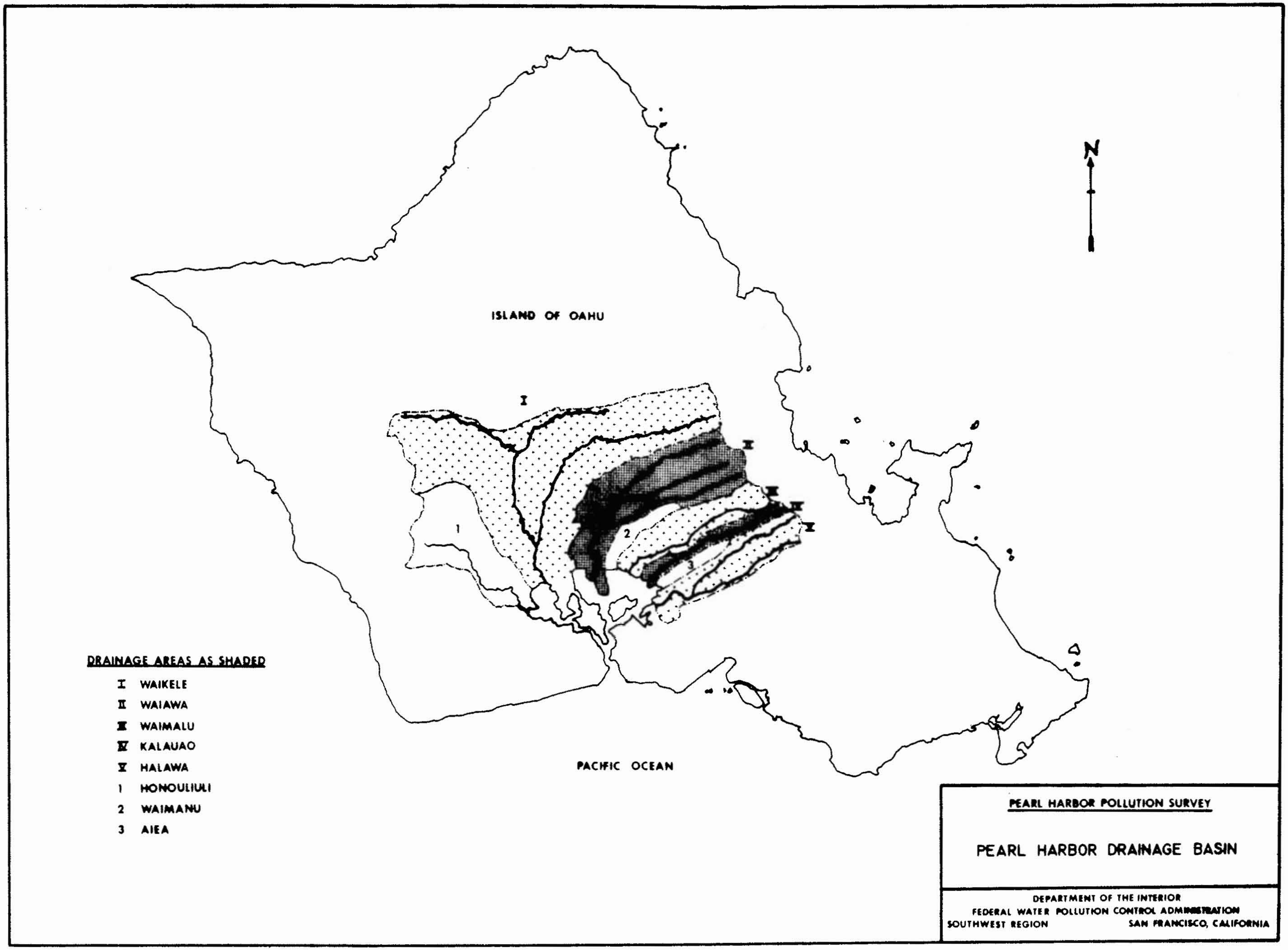
FRESH WATER SOURCES

Of the eight streams that enter Pearl Harbor, three are intermittent: Honouliuli Stream which enters West Loch, and Waimanu and Aiea Streams which discharge into East Loch. The others are perennial and have their head-waters in the Koolau mountain range. All of the streams drain agriculture lands planted in sugar cane and pass through urban areas before discharging into Pearl Harbor. Halawa, Waiawa, and Waikele Streams receive discharges from sewage treatment plants.

The area of the basin drained by the streams is 89.6 square miles (figure 1). The mean flow of five streams (Waikele, Waiawa, Waimalu, Kalauao, and Halawa) which have U. S. Geological Survey (USGS) gauges at lower elevations is 56 mgd, and minimal mean flow is 8 mgd. The average mean daily flow for these streams during the survey in January, February, and March 1969 was estimated at 177 million gallons.

In addition to the tributaries, five large ground water springs having an estimated mean flow of 87 mgd discharge into Pearl Harbor. East Loch receives 51 mgd; Middle Loch, 14 mgd; and West Loch, 22 mgd of the spring water. A small fraction of the spring water is diverted for irrigation of watercress and sugar cane. Waste water from artesian wells watering wetland crops such as taro and watercress is estimated by Visher and Mink (1964) to add 5 mgd to the fresh water input of the harbor.

Exclusive of waste discharges, the total supply of fresh



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ISLAND OF OAHU
I
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PACIFIC OCEAN
DRAINAGE AREAS AS SHADED
I WAIKELE
II WAIAWA
III WAIMALU
IV KALAUAO
V HALAWA
1 HONOULIULI
2 WAIMANU
3 AIEA
PEARL HARBOR POLLUTION SURVEY
PEARL HARBOR DRAINAGE BASIN
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHWEST REGION
SAN FRANCISCO, CALIFORNIA

FIGURE I

water entering Pearl Harbor during a dry period is estimated at 50 mgd. Because of tremendous load increases during the rainy season, the mean flow from all sources is estimated to be considerably over 100 mgd.

The following five perennial streams were sampled during January, February, and March 1969:

Halawa Stream

Halawa Stream discharges approximately 8 mgd into East Loch and drains an area of 8.8 square miles above the flood crest gauging station. Flow is primarily runoff from undeveloped land and some urban areas. The animal quarantine station discharges approximately 0.08 mgd of effluent into the stream from its secondary treatment plant.

Kalauao Stream

Kalauao Stream has a contributory area of 2.6 square miles above the gauging station. The stream drains a relatively undeveloped area. Discharge is to East Loch with mean flow averages for January, February, and March 1969 at 5.1 mgd.

Waimalu Stream

Waimalu Stream, which discharges into East Loch, has a drainage area of 6.1 square miles that is relatively undeveloped. The mean flow over the 3 month period was 14.4 mgd.

Waiawa Stream

Waiawa Stream discharges into Middle Loch from a drainage area of 26.4 square miles above the USGS gauge. Significant amounts of agricultural runoff and approximately 0.5 mgd of secondary treatment sewage effluent enter the stream. Mean flow over the 3-month period was 74.2 mgd.

Waikele Stream

Waikele Stream discharges into West Loch and drains 45.7 square miles of the Oahu Central Basin. In addition to runoff from the high mountain areas, the stream receives significant runoff from agricultural lands used for both sugar cane and pineapple cultivation. There is growing urbanization in the basin, and sewage treatment plant effluent totaling 3.8 mgd enters the stream. The arithmetic mean flow for the period January, February, and March 1969 was 75.6 mgd.

STREAM SURVEY RESULTS

The five streams surveyed showed a close continuity in temperature and pH values which were within the range for January and February.

Coliform values were higher than those allowed by State water quality standards which stipulate that median coliform values are not to exceed 1,000 organisms/100 ml for any 30-day period. In this survey, median coliform values ranged from a low 1,200 organisms/100 ml in Halawa Stream to 5,900 organisms/100 ml in Waiawa Stream. State water quality standards also require that fecal coliform content not exceed an average of 200 organisms/100 ml for any 30-day period. Halawa Stream contained average fecal coliform densities of 120 organisms/100 ml, while Waiawa Stream had an average fecal count of 5,000 organisms/100 ml.

Stream loadings for phosphorus and solids were calculated from the mean concentrations and flows of the streams surveyed. Waiawa Stream contribute 266 lbs/day of phosphorus to Pearl Harbor while Waikele Stream contributes 227 lbs/day.

Waikele Stream discharges an average of 9,900 pounds of solids into West Loch each day or approximately 1,875 tons annually. Over half of these solids is settleable. Waiawa Stream discharges 4,400 pounds of solids into Middle Loch each day. The other three streams discharge a daily combined weight of 3,475 pounds of solids into East Loch.

Temperature, pH, coliforms, phosphorus, and solids are summarized in table III. Table IV summarizes projected

TABLE III

SUMMARY OF STREAM SURVEY DATA

STREAM	TEMP. (°C)	pH*	COLIFORMS-MF (ORG/100 ML) TOT.*	FECAL	TOTAL PO_4 (MG/1)	SOLIDS (MG/1) SUSP.	SETTLE.
Halawa	21.1	8.0	1,200	120	0.079	24	7
Kalauao	20.5	7.8	1,500	580	0.035	11	7
Waimalu	20.7	7.6	3,500	1,250	0.032	13	7
Waiawa	20.5	7.6	5,900	5,000	0.430	13	7
Waikele	20.8	7.6	1,500	470	0.360	17	9

*Median values.

TABLE IV

PROJECTION OF MEAN DAILY STREAM LOADING OF FIVE STREAMS ENTERING PEARL HARBOR

STREAM	MEAN FLOW (MGD)	PHOSPHORUS (LBS/DAY)	SOLIDS (LBS/DAY) SUSPENDED	SETTLEABLE
Halawa	8	5.3	1,601	467
Kalauao	5.1	1.5	238	152
Waimalu	14.4	3.8	661	356
Waiawa	74.2	266.1	2,862	1,541
Waikele	75.6	277.0	6,479	3,430
TOTALS	177.3	553.7	11,841	5,946

stream loadings for phosphorus and solids.

OTHER WASTE SOURCES

Near the entrance to Pearl Harbor are two major sources of pollution which could influence water quality. First is the raw sewage discharge of 50 mgd from the city of Honolulu. Under normal conditions, this discharge drifts toward Pearl Harbor. The second source is the Keehi Lagoon area which receives untreated wastes from local industries and domestic sources. Studies of water currents have indicated that under certain conditions these wastes could affect water quality in Pearl Harbor.

Adjacent to the entrance to Pearl Harbor are two Federal installations which discharge wastes. They are Hickam Air Force Base and the Iroquois Point housing tract. At present, improvements have been programmed. Hickam will connect to the new Navy Sewage Treatement Plant and the Iroquois Point Sewage Treatment Plant is programmed for upgrading to secondary treatment by FY 1972.

V

EFFECTS OF WASTES ON WATER QUALITY

GENERAL

Of the three lochs in Pearl Harbor, West Loch showed the lowest water quality. Specifically, the area designated as Class AA had the poorest quality water of any area in the entire harbor. This low quality water was characterized by high coliform concentrations, low dissolved oxygen (DO), heavy silting, floating debris, and high nutrient values. The highest quality of water in the harbor was in East Loch and the main channel.

DISSOLVED OXYGEN

Dissolved oxygen is one of the most significant parameters of water quality. When an organic load such as that measured by the BOD test is imposed upon a body of water, dissolved oxygen is utilized in the stabilization process. Oxygen is transferred and dissolved from the atmosphere or from photosynthetic production by aquatic plants. Adequate levels of dissolved oxygen are necessary to support fish and other aquatic life. When total depletion of oxygen occurs, the waters become septic. Further decomposition produces hydrogen sulfide gas which creates obnoxious environmental conditions.

A severe oxygen depletion occurs in West Loch during the night. Early morning surface and subsurface values on March 25, 1969,were 0 mg/l at many stations in Class AA waters. During the daylight hours, values rose to over 10 mg/l in areas windward of the sewage discharge. It appears that West Loch is acting as a large oxidation pond in which DO values reach extremes during the day from phytoplankton activity and are then severely depleted at night.

TEMPERATURE

Temperature is a critical factor in the rearing of oysters. Maximum limits for survival of oysters range from 59 degrees F to 95 degrees F; however, mass spawning of oysters is reported to occur in the range of 71 degrees F to 89 degrees F. Temperatures in oyster-growing areas ranged from 73.5 degrees F. to 83 degrees F.; in the remainder of the harbor they ranged from 74 degrees F. to 81 degrees F. Possible temperature anomalies resulting from 86 degrees F. water discharged into East Loch from an Hawaiian electric plant and U. S. Navy power plants were not investigated.

SALINITY

The salinity requirements in the production of oysters range from 10 to 30 parts per thousand (ppt) with 25 ppt reported as the optimum level. During the study, salinity for the entire harbor, ranged from 23.6 ppt to 36.4 ppt. West Loch, with a large influx of fresh water from surface and subsurface sources, had the lowest salinity concentration in the harbor. Subsurface waters had salinities which were generally 3 ppt higher than surface waters. The top of the halocline ranged from 18 inches to 6 feet below the surface in West Loch. This phenomenon was less pronounced in other lochs because of the lower influx of fresh water.

NUTRIENTS (PHOSPHORUS AND TOTAL NITROGEN)

Human and animal feces contain phosphorus and nitrogen which serve as nutrients or fertilizer for both land and water plant life. Although other elements are necessary as nutrients for plant growth, deficiencies in phosphorus and nitrogen are believed to be the most common limits on aquatic plant growth. Current technology permits the design of treatment plants capable of removing these elements from sewage and industrial waste, while conventional treatment plants provide only slight reduction of these materials.

In West Loch, the Class AA water values ranged from 0.028 mg/l at Waikele to 0.650 mg/l adjacent to the raw sewage outfall. The average value for the Class AA area was 0.098 mg/l, five times the existing water quality standards. The remainder of the stations in West Loch, which are Class A, had values ranging from 0.026 mg/l to 0.086 mg/l and averaged 0.051 mg/l.

Entrance channel station ranges (EA, EB, EC, and EE) had average surface values of 0.034 mg/l and average bottom values of 0.024 mg/l, indicating some stratification effect between the outflowing surface waters and inflowing bottom oceanic waters. This effect was not apparent in the upper reaches of Middle and East Loch possibly because of the reported upwelling and mixing which take place there.

Surface and bottom values for Middle and East Loch ranged from 0.016 mg/l to 0.260 mg/l, with an average value of 0.051 mg/l.

Nitrogen data from Pearl Harbor are not conclusive; however, the results are noted for future reference. They show the average total nitrogen values, expressed as N of surface and subsurface stations in West Loch, Class AA waters, to be 0.44 mg/l and values in East Loch and channel stations to be 0.18 mg/l. No data are available for Middle Loch.

TOTAL COLIFORMS

Bacteria from human wastes constitute a major water pollution problem in Pearl Harbor. These bacteria originate, for the most part, from the discharge of untreated or inadequately treated domestic sewage.

Sewage contains readily detectable coliform bacteria which typically occur in excreta or feces. Though generally harmless in themselves, coliform bacteria are always present in sewage polluted water. Their presence therefore has been considered indicative of the probable presence of pathogenic bacteria.

Within recent years,a selective test has been developed to identify fecal coliform bacteria which specifically inhabit the intestinal tract of man and warm-blooded animals. The presence of these organisms in water is positive proof of fecal contamination which may contain associated disease-producing organisms such as Salmonella, an indicator of infectious hepatitis. The chain of disease transmission by pathogenic bacteria from human waste through shellfish which are eaten raw or improperly cooked has been well established.

The discharge of bacteria through raw and untreated sewage also creates a hazard to the health of persons coming in contact with the receiving waters in certain areas of Pearl Harbor.

More emphasis was placed on sampling surface coliform distribution in West Loch than in other areas of Pearl Harbor primarily because of the proximity of the oyster beds and the high water quality standards in the northwest end of this loch. This area, designated as Class AA waters by the State of Hawaii "Public Health Regulations," encompasses most of the major oyster beds in Pearl Harbor (figure 5). The water quality standards for Class AA water require that median total coliform bacteria level not exceed 70/100 ml, nor should samples exceed 230/100 ml at any time.

Coliform values from this survey are representative of dry conditons and therefore are lower than those which would be expected during winter months or after heavy unseasonal rains.

WEST LOCH (CLASS AA WATERS)

Median total coliform counts for Class AA waters ranged from 100/100 ml in the area south and west of Laulaunui Island to 670,000 ml in the vicinity of the Waipahu raw sewage discharge; therefore, none of the stations sampled during this survey met the water quality standards for total coliforms that are designated by the State public health laws.

Various tidal situations were encountered which affected surface coliform distributions. Figure 2 shows the effects of falling tide and figure 3, rising tide, on the distribution of coliform bacteria on different days.

Coliform distribution patterns could change in West Loch if the plantations were using raw sewage to irrigate cane lands south of the outfall. According to the plantations, however, this is not the usual practice.

WEST LOCH, MIDDLE LOCH, AND EAST LOCH (CLASS A WATERS)

Median total coliform values for Class A surface waters in

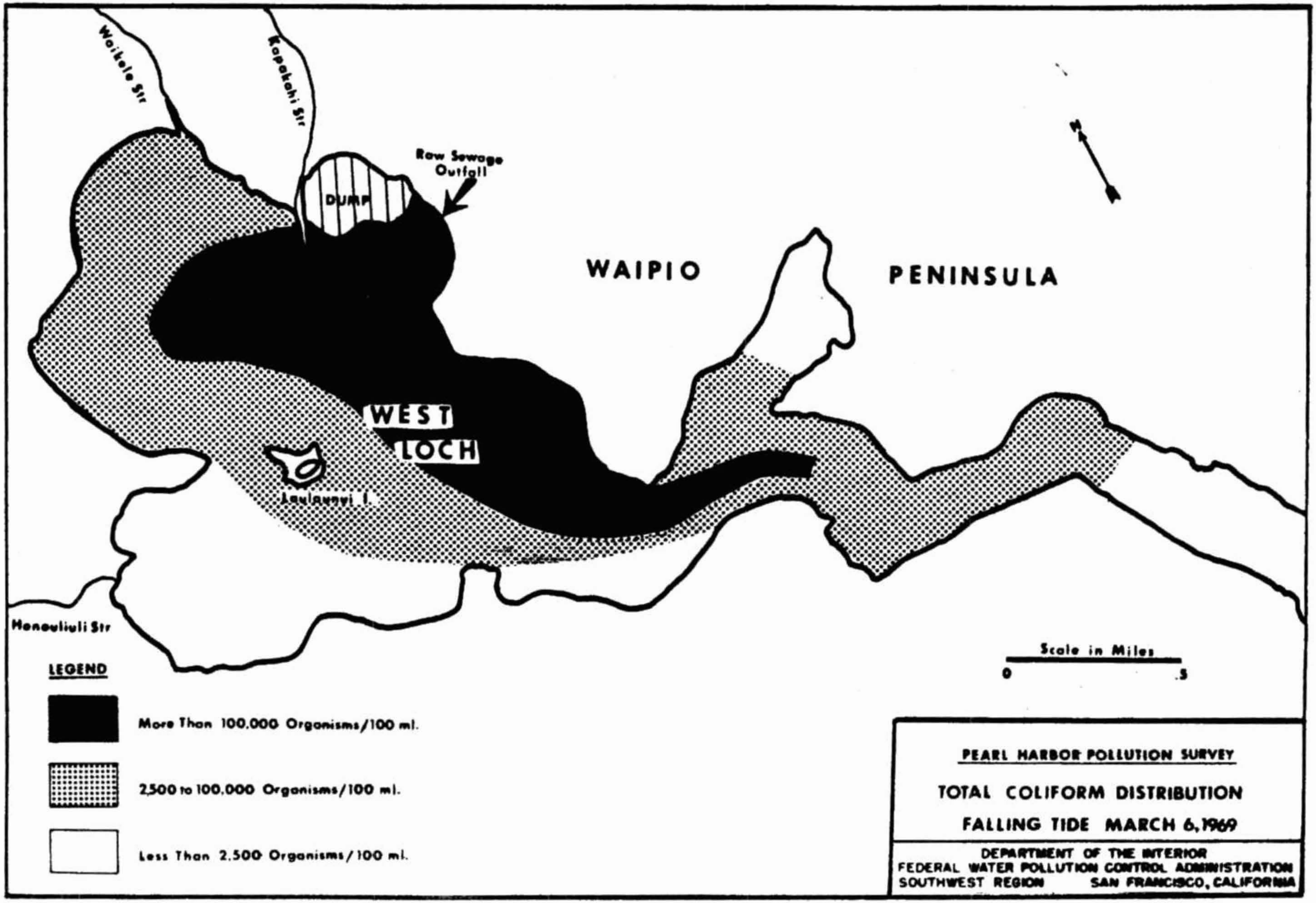
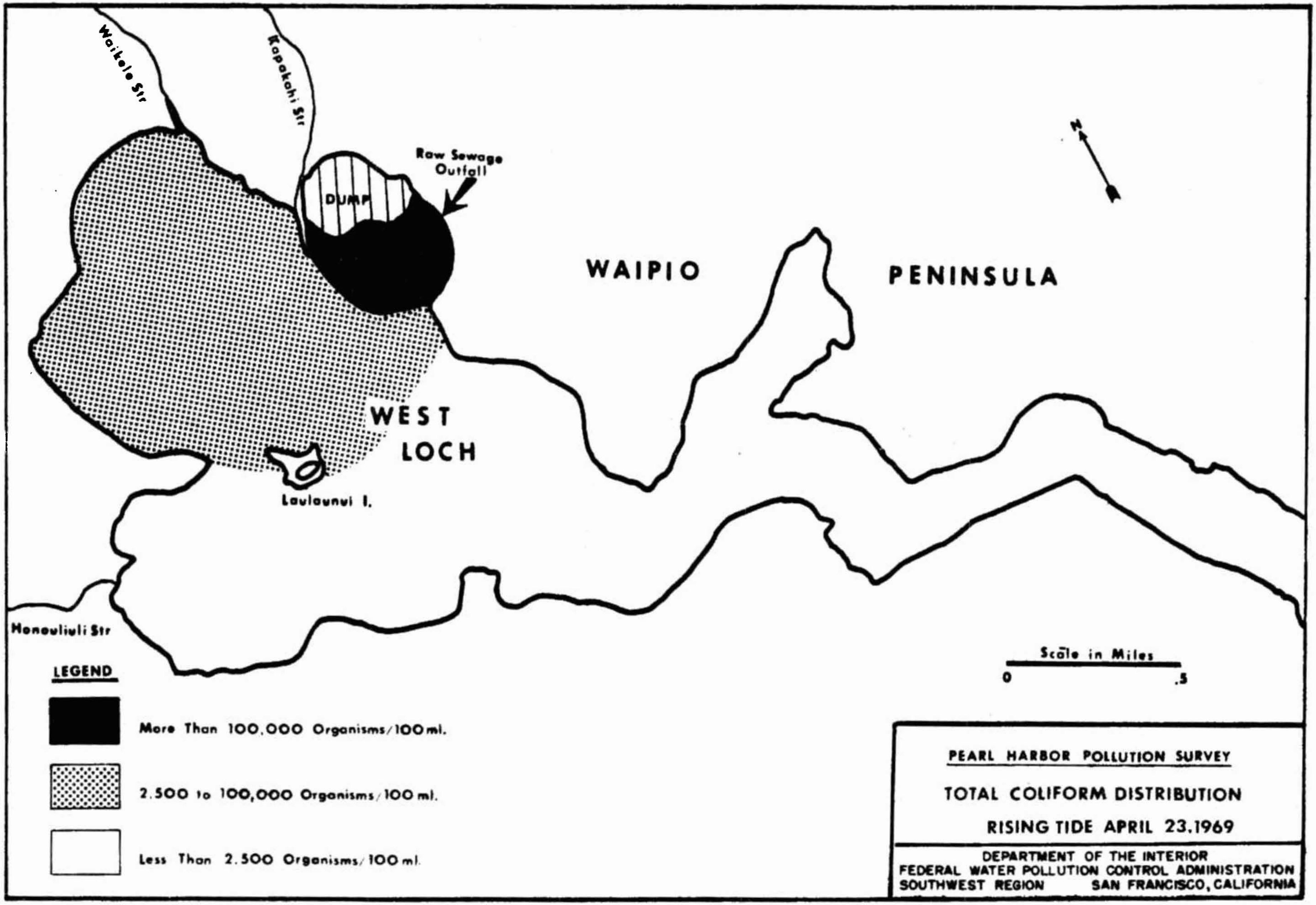

Waikele Str
Kapakahi Str
DUMP
Raw Sewage Outfall
WAIPIO
PENINSULA
WEST
LOCH
Honouliuli Str
Scale in Miles
0
.5
LEGEND
More Than 100,000 Organisms/100 ml.
2,500 to 100,000 Organisms/100 ml.
Less Than 2,500 Organisms/100 ml.
PEARL HARBOR POLLUTION SURVEY
TOTAL COLIFORM DISTRIBUTION
FALLING TIDE MARCH 6, 1969
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHWEST REGION
SAN FRANCISCO, CALIFORNIA

FIGURE 2



Waikele Str
Kapakahi Str
Raw Sewage Outfall
DUMP
N
WAIPIO
PENINSULA
WEST
LOCH
Laulaunui I.
Honouliuli Str
Scale in Miles
0
.5
LEGEND
More Than 100,000 Organisms/100 ml.
2,500 to 100,000 Organisms/100 ml.
Less Than 2,500 Organisms/100 ml.
PEARL HARBOR POLLUTION SURVEY
TOTAL COLIFORM DISTRIBUTION
RISING TIDE APRIL 23,1969
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHWEST REGION SAN FRANCISCO, CALIFORNIA

FIGURE 3

West Loch ranged from 3,000 to 33,500/100 ml.

Median total coliform values in Middle Loch ranged from less than 100 to 127,100/100 ml. The high value was collected from an apparent leak in the Pearl City Sewage Treatment Plant's outfall located about 50 feet from the shore line (SM 01). Sample values taken at this location ranged from 2,100/100 ml to 13,100,000/100 ml and indicated that on at least one day the plant was not chlorinating its wastes.

Other areas where high median total coliform values were observed include the raw sewage outfall belonging to the Navy (SE 01) and the Aiea raw sewage outfall (SE 05).

Total coliform data for all water quality sampling stations are presented in table V.

Table VI presents a comparison of three total coliform bacteriological surveys conducted in Pearl Harbor. While it is recognized that MPN and Milipore filter techniques are different, the trend is obvious especially in West Loch, Middle Loch, the Aiea Sewer outfall, and the Navy's outfall in the main channel, where there has been an increase in level of coliforms. The stations with decreased values are located at the mouth of Halawa and Waimalu Streams, Kalauao Stream, waters between the Navy's docks and Ford Island, and off the northeast portion of Waipio Peninsula. This decrease may be due to discontinuing the raw discharges.

FECAL COLIFORMS (MF)

The data presented cover two days and present a picture of the variation of values during the sampling period.

Figure 4 shows averages plotted for the two sampling days. Areas which exceed an average of 200 fecals per 100 ml are located adjacent to the major sewage outfalls and isolated spots around the Navy's piers. Table V shows results of fecal coliform sampling at water quality stations.

TABLE V

SUMMARY OF MF BACTERIOLOGICAL EXAMINATION

OF PEARL HARBOR SURFACE WATERS

	TOTAL COLIFORMS			FECAL COLIFORMS		
STA. NO.	NO. TIMES SAMPLED	MEDIAN MF/100 ML	RANGE MF/100 ML	NO. TIMES SAMPLED	MEAN MF/100 ML	RANGE MF/100 ML
STATIONS WITHIN CLASS AA WATERS						
WN 10	6	3,800	< 100 - 5,600	2	85	10 - 160
WN 20	8	4,900	500 - 24,000	2	295	100 - 490
WN 30	8	4,900	1,500 - 22,000	2	275	80 - 470
WF 10	7	80,000	16,000 - 760,000	2	54,050	100 - 108,000
WF 20	7	32,000	1,200 - 160,000	2	355	70 - 640
WH 10	8	670,000	280,000 - 24,000,000	2	312,500	210,000 - 415,000
WH 20	8	150,000	111,000 - 1,000,000	2	295,500	7,000 - 584,000
WE 10	8	9,350	700 - 44,000	2	350	100 - 600
WE 20	8	69,500	6,000 - 380,000	2	17,400	800 - 34,000
WE 30	8	49,500	7,000 - 690,000	2	2,500	500 - 4,500
WM 10	8	200	0 - 18,000	2	30	10 - 50
WM 20	8	300	0 - 91,000	2	35	30 - 40
WM 30	8	100	< 100 - 2,900	2	15	10 - 20
STATIONS WITHIN CLASS B WATERS						
WC 10	8	12,500	600 - 300,000	2	655	10 - 1,300
WC 20	8	20,500	1,000 - 180,000	2	710	20 - 1,400
WC 30	8	23,500	< 100 - 190,000	2	745	90 - 1,400
WB 10	8	5,050	100 - 160,000	2	135	10 - 260
WB 20	8	4,200	< 100 - 65,000	2	45	20 - 60

Table V-Continued

	TOTAL COLIFORMS			FECAL COLIFORMS		
STA. NO.	NO. TIMES SAMPLED	MEDIAN MF/100 ML	RANGE MF/100 ML	NO. TIMES SAMPLED	MEAN MF/100 ML	RANGE MF/100 ML
WA 10	10	3,650	40 - 23,000	4	10	0 - 20
WA 20	10	3,550	<100 - 24,000	4	30	10 - 60
WA 30	10	3,000	<100 - 17,000	4	35	<10 - 30
EA 10	5	<100	70 - 1,200	2	<10	<10 - 10
EA 20	5	240	<100 - 2,600	2	<10	<10
EA 30	5	220	10 - 1,200	2	<10	<10 - 10
EB 5	4	1,490	<100 - 2,700	2	325	130 - 520
EB 10	5	500	<100 - 1,600	2	55	50 - 60
EB 20	5	1,800	<100 - 5,100	2	170	100 - 240
SE 01	6	1,300,000	400,000 - 3,000,000	2	335,000	290,000 - 380,000
EC 10	5	3,400	<100 - 3,900	2	1,070	540 - 1,600
EC 20	5	4,200	<100 - 19,000	2	410	300 - 520
EC 30	5	1,500	700 - 6,000	2	260	<100 - 420
EE 10	5	19,000	<100 - 35,000	2	2,890	280 - 5,500
EE 20	5	2,200	<100 - 7,100	2	1,600	200 - 3,000
EE 30	5	1,300	90 - 2,600	2	110	90 - 2,600
MB 10	5	860	<100 - 37,000	2	155	<10 - 300
MB 20	5	580	<100 - 7,000	2	30	10 - 50
MB 30	5	2,000	100 - 5,600	2	170	20 - 320
ME 10	3	160	<100 - 1,800	2	200	40 - 360
ME 20	4	<100	60 - 2,800	2	10	<10 - 10
SM 01	4	127,100	2,100 - 13,000,000	2	3,000,000	100,000 - 5,900,000
MA 10	5	8,000	<100 - 530,000	2	13,450	1,900 - 25,000
MA 15	4	3,250	<100 - 60,000	2	930	160 - 1,700
MA 20	5	1,800	<100 - 5,300	2	255	170 - 340
MA 25	4	20,550	<100 - 84,000	2	15,600	3,200 - 28,000
MA 30	5	26,000	1,800 - 133,000	2	13,600	3,200 - 24,000
MF 10	4	21,000	<100 - 38,000	2	2,400	700 - 4,100
MF 20	4	425	<100 - 68,000	2	55	20 - 90

TABLE V-Continued

	TOTAL COLIFORMS			FECAL COLIFORMS		
STA. NO.	NO. TIMES SAMPLED	MEDIAN MF/100 ML	RANGE MF/100 ML	NO. TIMES SAMPLED	MEAN MF/100 ML	RANGE MF/100 ML
EH 10	5	100	10 - 62,000	2	40	<10 - 70
EH 20	4	125	10 - 42,000	2	10	10
EH 30	5	330	20 - 30,000	2	10	10
EM 10	3	140	10 - 200	2	<10	<10
EN 10	5	<100	<10 - 1,100	2	<10	<10
EN 20	4	90	60 - 200	2	<10	<10
EN 30	5	200	60 - 4,500	2	<10	10 - <10
EP 20	5	1,200	820 - 5,700	2	970	340 - 1,600
SE 05	3	3,100,000	10,000,000 - 360,000	2	1,700,000	1,400,000 - 2,000,000
SE 04	3	300	210 - 1,300	2	495	80 - 910
ER 10	5	600	30 - 8,100	2	255	<10 - 500
ER 20	5	200	40 - 400	2	10	<10 - 10
ER 40	5	200	90 - 400	2	35	10 - 60
SE 02	3	1,400	400 - 2,700	2	230	100 - 360
SE 03	3	240	210 - 1,300	2	15	10 - 20
ET 10	5	1,600	200 - 5,200	2	8,900	3,800 - 14,000
ET 20	5	460	120 - 1,100	2	15	10 - 20
ET 30	5	460	110 - 1,100	2	40	<10 - 70
EV 10	5	400	0 - 14,000	2	1,125	50 - 2,200
EV 20	4	385	100 - 630	2	135	80 - 90
EV 30	5	300	80 - 600	2	25	20 - 30

TABLE VI

COLIFORM VALUES FROM SIMILAR STATIONS OF THREE SURVEYS IN PEARL HARBOR

STATION NO.*	1952** MPN	1961*** MEDIAN MPN	1969**** MEDIAN MF
EB 20	240	-	1,800
SE 01	240	-	1,300,000
EV 30	13	-	300
ER 20	240	-	200
SE 04	6,200	-	300
SE 05	6,200	-	3,300,000
EP 20	240	-	1,200
Kalauao Stream	6,200	-	1,500
EN 30130,000	-	200	
EM 10	2,400	470	140
EM 30	-	240	330
MA 30	23	700	26,000
MF 10	240	3,800	21,000
EC 30	-	1,300	1,500
WA 20	620	-	3,550
WC 30	240	-	23,500

* Station locations in figure A2, app. A, this report.

** City and County, Honolulu, 1958.

*** Austin Smity & Associates, and Metcalf and Eddy, 1961.

**** Table V, this report.

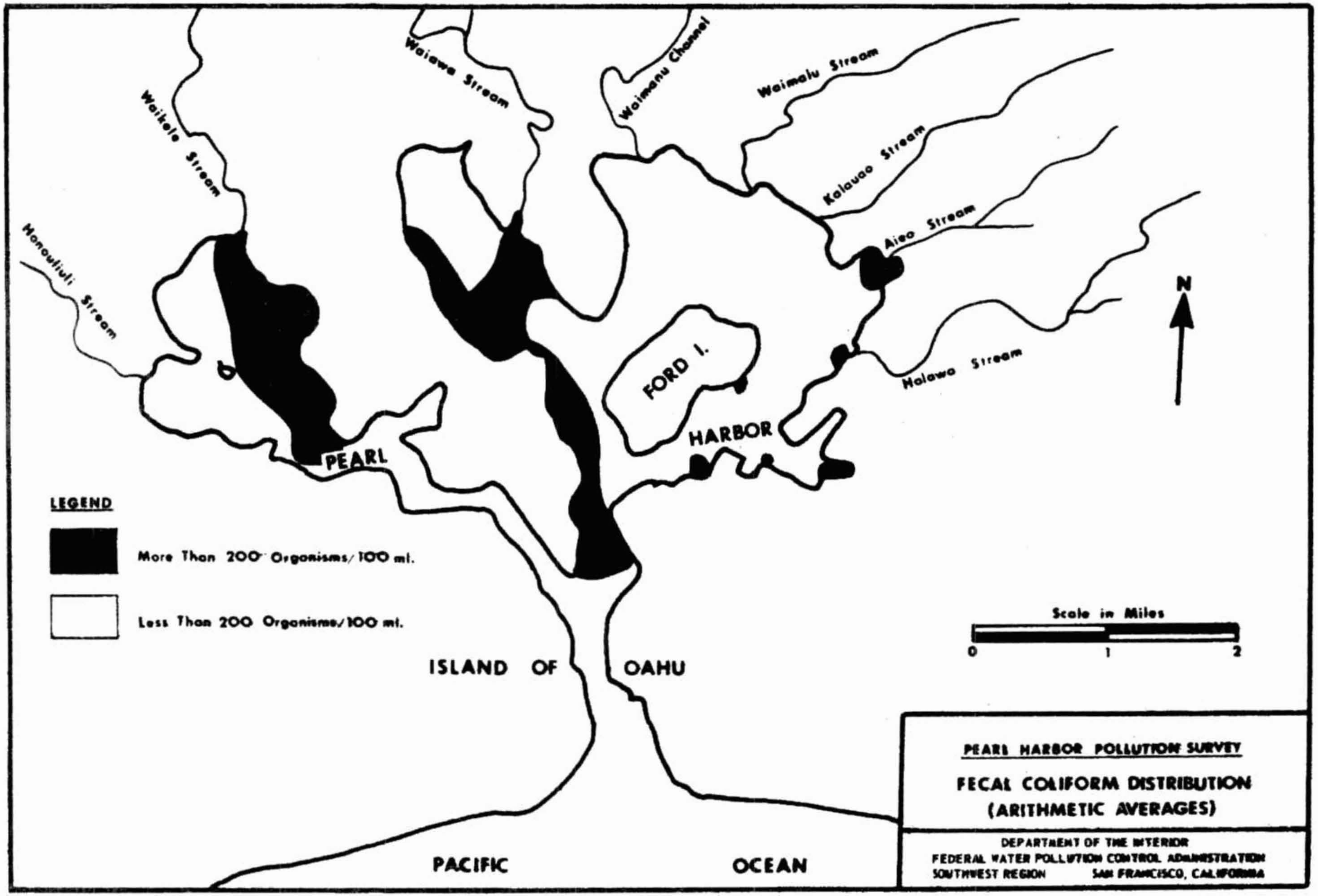

Waikele Stream
Waiawa Stream
Waimanu Channel
Waimalu Stream
Kalauao Stream
Aiea Stream
Halawa Stream
Honouliuli Stream
FORD I.
PEARL
HARBOR
N
LEGEND
More Than 200 Organisms/100 ml.
Less Than 200 Organisms/100 ml.
Scale in Miles
0
1
2
ISLAND OF OAHU
PACIFIC
OCEAN
PEARL HARBOR POLLUTION SURVEY
FECAL COLIFORM DISTRIBUTION
(ARITHMETIC AVERAGES)
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHWEST REGION
SAN FRANCISCO, CALIFORNIA

FIGURE 4

EFFECTS OF POLLUTION ON OYSTERS

Extensive beds of the Eastern oyster, _Crassostrea virginica_, are located in West Loch. In 1962, Sparks estimated that 55,630 bushels of live oysters were present in 150,000 square yards of major beds. He also found that the waters and oyster meats contained high levels of total and fecal coliforms which rendered them unfit for direct human consumption. Since then the Division of Fish and Game, State of Hawaii, in an attempt to utilize this potentially marketable resource, has experimented with depuration studies by relaying oysters to fish ponds for cleaning and growing. At this writing, none of the Pearl Harbor oysters has been marketed under the sanction of the State.

The locations of the oyster beds in West Loch are shown in figure 5. The State water quality standards have designated the waters north of the dotted line in figure 5 as Class AA, the highest usage to which any waters can be assigned for shellfish propagation, marine research, and conservation.

The median value of 420 coliforms per 100 ml of water found by this survey exceeds the State of Hawaii standard of 70/100 ml for Class AA waters. The median value of 410 fecal coliforms (EC test) /100 gm of shellfish meat and liquor also exceeds the limit for marketable shellfish which has been established at 230/100 gm by the National Shellfish Sanitation Program. Results of the completed test for coliform bacteria established that 27 percent of the 162 positive tubes contained _Escherichia coli_ of IMVIC type I or II, indicating that these waters are polluted by human wastes.

These coliform findings concur with both Sparks' (1963) and a sanitary survey conducted by the U. S. Navy in 1966 (unpublished date) which indicated the presence of a health hazard to persons eating West Loch oysters taken directly from the area without a period of depuration. The results of this survey are compared with the two previous surveys in table VII.

Since rainfall was minimal during the sampling period, the

FIGURE 5

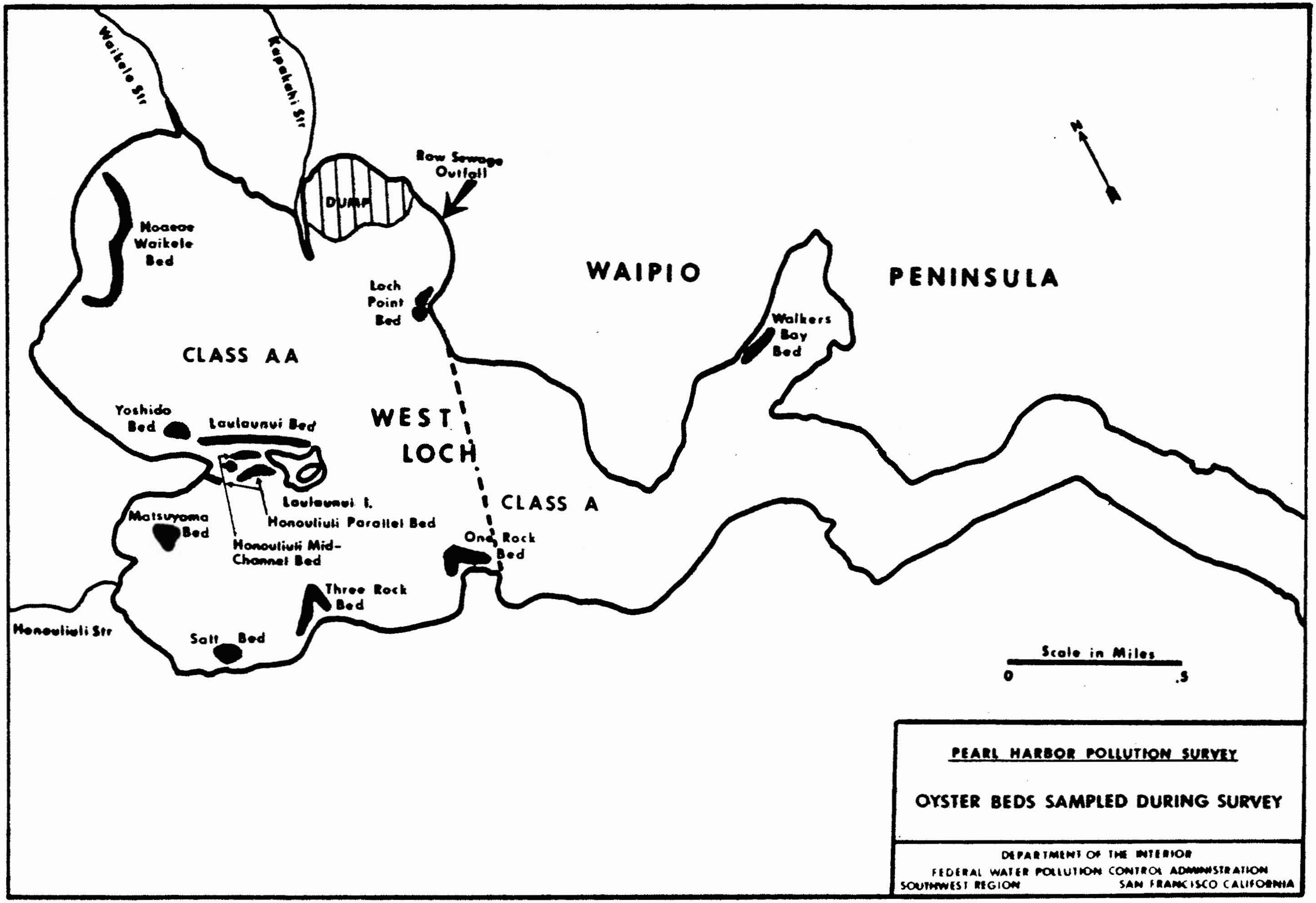

Waikele Str
Kapakahi Str
DUMP
Raw Sewage Outfall
Hoaeae Waikele Bed
Loch Point Bed
WAIPIO
PENINSULA
Walkers Bay Bed
CLASS AA
WEST LOCH
Yoshida Bed
Laulaunui Bed
Laulaunui I.
Honouliuli Parallel Bed
Honouliuli Mid-Channel Bed
Matsuyama Bed
CLASS A
One Rock Bed
Three Rock Bed
Salt Bed
Honouliuli Str
N
Scale in Miles
0
.5
PEARL HARBOR POLLUTION SURVEY
OYSTER BEDS SAMPLED DURING SURVEY
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHWEST REGION
SAN FRANCISCO CALIFORNIA

TABLE VII

COLIFORM VALUES OF THREE SURVEYS FROM SIMILAR OYSTER BEDS IN WEST LOCH, PEARL HARBOR

	SPARKS' 1962 SURVEY		U.S. NAVY 1966 SURVEY		FWPCA 1969 SURVEY	
LOCATION AND SOURCE	COLIFORMS	FECAL COLIFORMS	COLIFORMS	FECAL COLIFORMS	COLIFORMS	FECAL COLIFORMS
ONE ROCK						
Water	23,000	6,200	20,080		970	112
Oysters	24,000,000	24,000,000	15,650	80,680	9,200	2,400
THREE ROCK						
Water	620	230	10,170		240	65
Oysters	2,400,000	2,400,000	4,700	4,700	2,400	220
WALKER BAY						
Water	620	230	8,540		725	130
Oysters	23,000	620	503,000	251,000	17,000	1,400
HOOEAE-WAIKELE						
Water	215,100	10,500			230	70
Oysters	230,000	105,000	133,130	25,433	1,700	350
LAULAUNUI						
Water	23,000	6,200			1,595	355
Oysters	620,000	62,000	39,670	13,900	5,400	920
SALT						
Water	2,300	60	9,470		180	45
Oysters	2,300,000	Negative	4,700	4,700	1,300	350
HONOULIULI						
Water	620	620			790	440
Oysters	62,000	Negative			5,400	<330

TABLE VII-Continued

LOCATION AND SOURCE	SPARKS' 1962 SURVEY COLIFORMS	SPARKS' 1962 SURVEY FECAL COLIFORMS	U.S. NAVY 1966 SURVEY COLIFORMS	U.S. NAVY 1966 SURVEY FECAL COLIFORMS	FWPCA 1969 SURVEY COLIFORMS	FWPCA 1969 SURVEY FECAL COLIFORMS
HONOULIULI PARALLEL						
Water	6,200	Negative			490	155
Oysters	620,000	230,000	307,960	133,870	4,900	490
MASUYAMA FISH POND						
Water	2,300	620			230	440
Oysters	23,000	60			790	<230
LOCH POINT						
Water					>240,000	240,000
Oysters					9,200,000	1,600,000

Notes:
1. Where more than one sample was taken from one location during a survey, results are presented as averages.
2. Navy's water data are MF/100 ml water; others are MPN/100 ml water.
3. Oyster values are MPN/100 g of oyster meats.

coliform levels found probably represent lower levels that would normally be found during drier weather. The higher coliform values found by Sparks and the U. S. Navy were acquired during periods of intermittent heavy rainfall.

The major source for fecal contamination is the raw sewage discharge of approximately 2 mgd from the town of Waipahu into the east side of West Loch (figure 5). The adjacent city dump also probably contributes to the problem.

Tests for the presence of pathogenic bacteria of the genus Salmonella resulted in isolating and identifying at least one serotypic species (group E1) in oyster meats from Lock Point bed. This isolation was subsequently identified as Salmonella weltevreden by the National Communicable Disease Center, Atlanta, Georgia.

ECONOMIC DAMAGE TO OYSTER RESOURCE

In his 1962 survey, Sparks estimated that there were approximately 31 acres of oyster beds in West Loch containing approximately 35,500,000 live oysters. According to accepted shellfish harvesting practices, all oysters 3 or more inches in length would be suitable for harvesting. This means that about 27 percent of the West Loch oysters would be suitable for harvesting. In view of the rapid growth rate of oysters in Pearl Harbor and providing that the resource was properly managed this production could most probably be sustained on an annual basis.

The current value of Olympia oysters to a producer in the State of Washington is 60 cents per dozen. Using this dockside value as a basis, the oyster resource in West Loch would have a minimum potential market value to the grower, the State of Hawaii, of approximately $480,000.

The Hawaiian oysters are the same species as the Eastern oysters, Crassostrea virginica. Commanding a dockside price ranging from $1.50 to $4 per bushel, they are a much more valuable species than the Olympia oyster.

A recent survey of the Florida shellfish industry and its price structure indicated that the final retail value of shellfish products is roughly four times the dockside value.

The 1969 FWPCA survey of Pearl Harbor indicated that siltation was responsible for a net decrease of 58 percent in the size of ten oyster beds in West Loch. Assuming that the size distribution of live oysters on the beds has remained the same since 1962 and that all beds have been reduced in size by approximately 50 percent, then the minimum potential value of the oyster resource would be cut in half, with the present value being approximately $240,000.

If measures are taken to reduce the silting, and to carefully manage the oyster resource, it is expected that the size of the oyster beds could be increased. Following sections of this report contain a more detailed discussion of the effects of silting on the oyster beds.

FLOATING DEBRIS AND OIL

One of the basic water quality standards of the State of Hawaii which is applicable to all water areas requires that waters be free of floating debris and oil. The fact that this standard is being violated in Pearl Harbor is obvious to the most casual observer.

The city and county of Honolulu's dump, located in the northeast corner of West Loch in sight of the former Kekona Fish Pond (figure 5), is the largest contributor of floating debris in West Loch. In addition to being an eye sore, floating cans, bottles, automobile tires, and charred trash from the dump present a hazard to boat navigation. The water-borne debris is blown by northeast winds and piles up on the shores of Laulaunui Island and surrounding oyster beds. The many cans, plastic bottles, lumber, appliances, and large drums that litter the shore line of West Loch are a product of the dump. This debris is pushed into the water by bulldozers as expansion of the dump encroaches outward into the estuary.

Extensive oil slicks were observed in the main channel and in East Loch on the east side of Ford Island adjacent to the Navy piers. Although the Navy attempts to clean up the spilled oil with a skimmer barge, it is not completely successful. Some leakage along the shore line is caused by old ruptured oil pipes and old abandoned tanks. The Navy is attempting to locate this source of oil and take corrective measures.

SUSPENDED SOLIDS

Suspended solids in sewage include large proportions of decomposable organic material. The major source of such suspended solids is the discharge of untreated or inadequately treated domestic sewage. Adequate treatment facilities are capable of removing 90 to 95 percent of such material from municipal and industrial wastes.

Upon discharge to the receiving waters, the suspended solids immediately impart a grey turbidity to the waters and diminish their aesthetic appeal. The heavier solids settle to the bottom in the vicinity of the points of discharge and form objectionable and harmful sludge deposits. The organic material in the sludge undergoes a decomposition process which at times lowers the dissolved oxygen level in the overlying waters to below the level of survival needed by fish and other aquatic life.

EFFECTS OF SILTING ON SIZE OF OYSTER BEDS IN WEST LOCH

Preliminary surveys in West Loch indicated a possible reduction in the size of oyster beds since Sparks' survey in 1962. To verify this presupposition, aerial photographs of the area were taken by the U. S. Navy Fleet Air Photographic Laboratory during low tide on February 18, 1969. Only measurements of the major exposed beds were taken from the photographs, and a field survey was made to verify the presence of oysters on these beds.

The results of this survey are compared with Sparks' survey in figure 6. There has been approximately a 50 percent average decrease in the size of the oyster beds compared. This reduction has been accomplished in a period of 7 years. Diminution in the area of oyster beds, especially in the north end of West Loch, is apparently caused by silt coming from Waikele Stream and by discharges of sugar mill wastes from Oahu Sugar Company.

Field surveys showed that oysters were growing in deep mud and that mangroves covered large portions of the Hoaeae-Waikele and Laulaunui beds. Oyster shells were present under the mangroves, but live oysters were not seen there. Oysters that were growing in the mud had elongated shells, were buried about half their length, and had attached themselves to dead shells that were completely buried in the sediment. Loch Point bed contained barely enough live oysters for the coliform tests, and the Waikele Point bed was nonexistent.

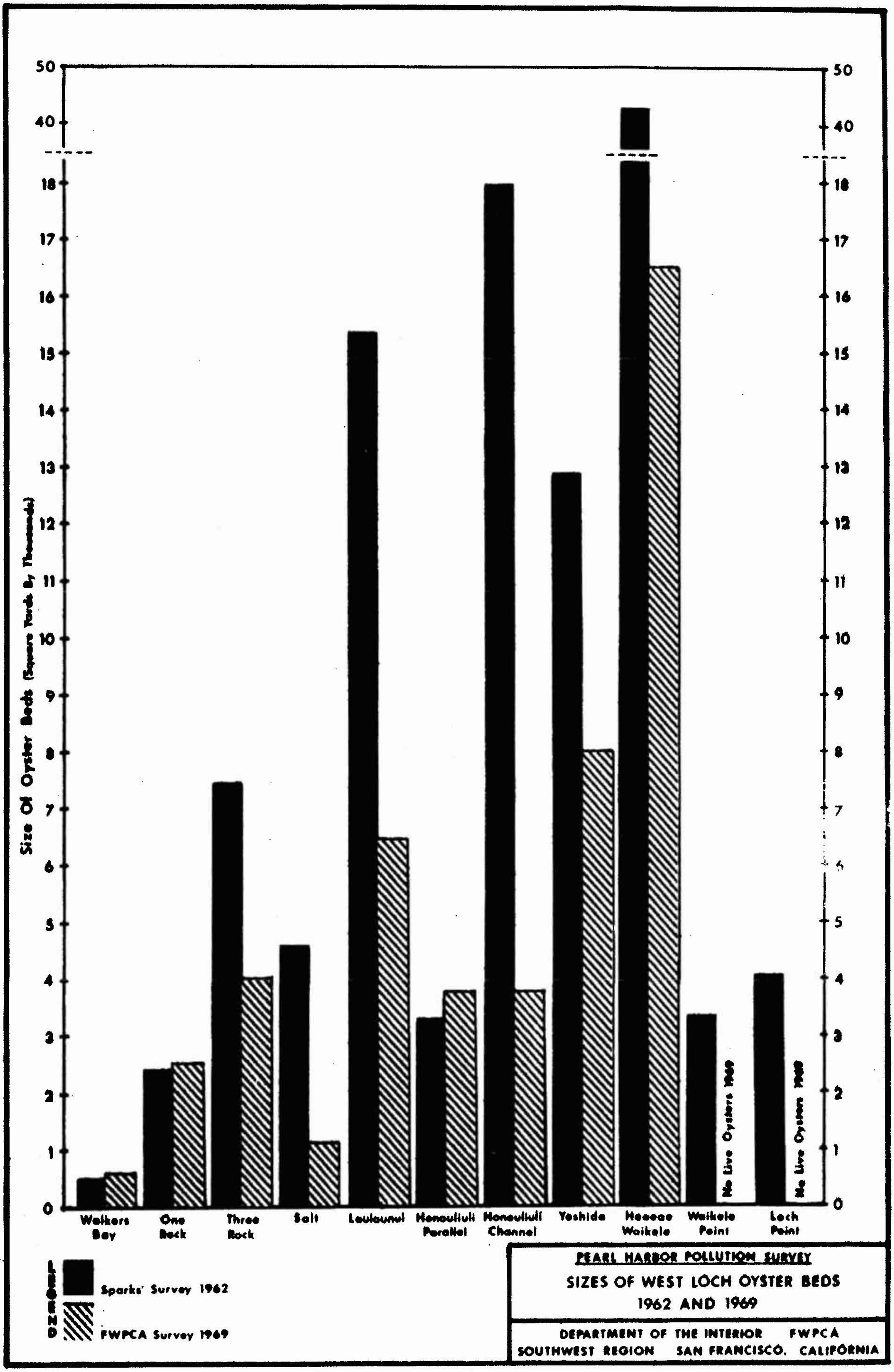
Even though the results of this survey were taken from only the exposed oyster beds that could be measured by aerial photographs, it is obvious that unless steps are taken to reduce the present rate of silting in the north end of West Loch, a valuable resource of the State will be completely destroyed in the matter of a few years.

BOTTOM CONDITIONS

Deposits of silt and other settleables are filling in the area of West Loch waters zoned Class AA. Depth of silting is over 8 feet in the undredged area between Laulaunui Island, the sewer outfall, and Waikele (figure 5).

Sediments are a blackish, brown-colored organic sludge having a puddinglike consistency. A strong rotten-egg odor (hydrogen sulfide) is present in the sediments around the sewer outfall. As distance from the outfall increases, the odor of the sludge changes to a musty, swampy smell.

No microbenthic organisms were found in the soft sediments, indicating extreme biological degradation. A similar condition also exists in the upper reaches of Middle Loch; however, occasional dredging there by the Navy prevents a



50
40
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Size Of Oyster Beds (Square Yards By Thousands)
Walkers Bay
One Rock
Three Rock
Salt
Laulaunui
Honouliuli Parallel
Honouliuli Channel
Yoshida
Hoeeae Waikele
Waikele Point
Loch Point
No Live Oysters 1969
No Live Oysters 1969
LEGEND
Sparks' Survey 1962
FWPCA Survey 1969
PEARL HARBOR POLLUTION SURVEY
SIZES OF WEST LOCH OYSTER BEDS
1962 AND 1969
DEPARTMENT OF THE INTERIOR FWPCA
SOUTHWEST REGION SAN FRANCISCO, CALIFORNIA

FIGURE 6

deep build-up of silt.

The undredged portion of East Loch was too shallow for the project boat. The bottom sediments there are reddish brown in color and appear to result from sediment runoff.

In the dredged channels, sediments have a fine texture much like coral dust and are probably residue from the dredging operation. No benthic life was observed in the channel sediments, but the sides of the channels, supporting tunicates, sponges, crabs, and tubeworms indicate improvement in the biological environment. Oysters are attached to just about all hard substrates within the tidal zone in West Loch and Middle Loch.

VI

PROGRAMS FOR POLLTUION ABATEMENT IN PEARL HARBOR

CITY AND COUNTY OF HONOLULU

The Waipahu sewerage system was installed 42 years ago. It was designed for a life of 25 years, with an anticipated average sewage flow of 2.5 mgd and a peak flow of 4 mgd. Irrigation of sugar cane was the method selected for sewage disposal. Under an agreement which expired in 1952, the Oahu Sugar Company assumed all operation and maintenance costs of the city and county-built pumping station which fed the irrigation reservoir.

On September 17, 1956, the city and county of Honolulu resumed operation and maintenance of the pumping station, with the proviso that during the next 20 years Oahu Sugar Company would have sole claim to the effluent for as long as it should desire. The Oahu Sugar Company could at any time terminate acceptance of the untreated sewage effluent, with the responsibility for final disposal of the sewage effluent resting with the city and county government (City and County of Honolulu, 1957).

The Aiea sewerage system was built as the result of a typhoid epidemic in 1932, and by 1934 the initial phase was in place. Sewage was fed raw into a 10-inch cast-iron outfall emptying into 10 feet of water at the East Loch of Pearl Harbor. Until December 1941 when the United States entered World War II, there were no sewerage improvements of appreciable magnitude in the Pearl Harbor Basin. The building activity that accompanied World War II was solely for and under the Department of Defense.

In the early 1950's, a combination of various factors generated new interest in the need for enlarging the scope of sewerage construction.

The first of these incidents was the publication of a report in 1950 by the Hawaiian Academy of Science. In this publication, Dr. H. L. Arnold reported on observations of several cases of dermatitis which had occurred since 1948. The incidence of this infection, commonly called "Pearl Harbor Itch," occurred most frequently at points where pollution from sewage was greatest.

Secondly, the water supply and public health officials were concerned about contamination of commercially popular watercress by irrigation water polluted with cesspool leachate.

Third, the U. S. Navy became increasingly cognizant of growing pollution in the waters of Pearl Harbor. They anticipated that 1960 would find them with the necessary funds to begin work on a solution to the waste disposal problem in their own responsible areas. The city felt motivated to match this effort.

Fourth, land developers indicated a willingness to install sanitary sewers within their proposed subdivisions if the necessary trunk sewers were made available. Concurrently, homes and establishments relying on cesspools reported increasing difficulties and failures in the Pearl City-Waiau and Aiea-Halawa areas.

During August 1951, officials of the city and county met with representatives of the U. S. Navy and Army to plan a common effort, general "clean up" of Pearl Harbor waters. As a result of this meeting, two areas of study were selected, studied, and reported upon. The first area included those parts of the peripheral lands administered by the Pearl Harbor Naval Shipyard, and the other area covered a portion of the drainage watershed centered at Pearl City. At that time, these reports did not consider the problems caused by expansion of the communities at Halawa, Aiea, and Waimalu.

To meet these problems, two master plan reports were prepared for the Pearl Harbor Basin. "A Report of Sewage Master Plan for Waipahu, Ewa, Oahu" was completed by the City of Honolulu in November 1957. The primary purpose of the proposed study was to satify desirable water quality standards through the development of a program for the collection and disposal of liquid waste originating from the drainage basins on the island of Oahu. This program would include: (1) substantial field investigation of the terrestrial, aquatic, and marine environment; and (2) consideration of available scientific, engineering, and economic information, including data that have been or may be developed by other firms and agencies.

A study entitled "Report on Sewerage Master Plan for Aiea to Pearl City, Ewa, Oahu" was prepared by the city and county of Honolulu in 1958. It covered all the developable lands immediately north of Pearl Harbor. The report envisioned the collection of military and civilian-originated sewage from scattered facilities, conveyance through a common conduit system to a single plant site for primary treatment, and discharge by outfall into Pearl Harbor's Middle Loch. The site of the sewage treatment plant is on the Navy-owned Waiawa portion of Pearl City Peninsula. Recommendations of this plan have been instituted and are near 100 percent completion (table VIII).

In December 1959, the Navy contracted the private engineering firm of Austin Smith and Associates to report on the feasibility of eliminating all raw sewage discharges from Pearl Harbor and the overall scope of a project to accomplish the work required.

The report recommended that construction of two separate systems appeared to be the most feasible solution to eliminate raw sewage flows into Pearl Harbor waters. All sewage flows from areas adjacent to the master-planned city and county main would flow by gravity or be pumped into this main for transmission to the proposed city and county treatment plant at Pearl City. The second sewerage system would collect all sewage flows that could not economically be directed to the city and county main and bring them to a main pumping station. This main pumping station would then pump the collected sewage to a treatment plant, with final disposal through an ocean outfall. The basic recommendations of this report are expected to be 100 percent instituted by early 1970.

STATE'S PROGRAM FOR POLLUTION ABATEMENT IN PEARL HARBOR

The water pollution program for the State of Hawaii is administered through the State Health Department, Environmental Health Division. The program has concentrated on the establishment and implementation of water quality standards. The Environmental Health Division has also contracted with private laboratories for special studies to identify existing water quality. In addition to this, the State has required monitoring water quality from waste dischargers in the State. This program is being implemented through the permit requirements in the water

TABLE VIII

CITY AND COUNTY OF HONOLULU SEWAGE TREATMENT PLANTS

FY COMPLETED	DESCRIPTION	OPERATIONAL	DESIGN FLOW	COST ($1,000)	TREATMENT	METHOD OF EFFLUENT DISPOSAL	LOCATION
1958	*Waimalu Septic Tank 60' diameter, structural steel	No	--	53.0	Primary	Outfall into East Loch of Pearl Harbor	Waimalu
1961	City Jail STP and outfall	Yes	0.094 mgd	149.0	Trickling filter secondary treatment plant	Disposal into South Halawa Stream	Halawa Valley
1961	*Kalauao STP	No	3.52 mgd		Primary w/CHLOR	Disposal by outfall into East Loch	Kalauao
1961	Halawa Hills Estate; primary subaqueous outfall	Yes	0.486 mgd	300.0	Primary w/CHLOR	Outfall into East Loch	Halawa
1965	Waipahu Sewage Pump Station; replaces station built in 1924	Yes		444.8	Raw	Open ditch into West Loch or sugar cane irrigation	Waipio Peninsula, Waipahu
1966	Pearl City STP Phase 1	Yes	Dry weather 4.00 mgd Normal 5.00 mgd Wet weather 7.35 mgd, design pop. 32,500	2,810.1	Primary w/CHLOR 35% BOD removal, 64% SS removal	Outfall into Pearl Harbor, Middle Loch	Pearl City Peninsula
1967	Waipahu sewage site preparation	No		148.0 spent to FY 1967			Waipahu

*These units phased out; wastes collected and pumped to Pearl City Sewage Treatment Plant for disposal.

quality standards.

DEPARTMENT OF DEFENSE PROGRAM FOR POLLUTION ABATEMENT IN PEARL HARBOR

In keeping with the increasing concern about pollution of the nation's estuaries, the U. S. Navy has authorized actions to abate the pollution of waters in Pearl Harbor, Hawaii.

Consulting engineering firms have recently submitted their reports on field studies and engineering planning of Pearl Harbor, with special emphasis placed on domestic and industrial wastes and vessel pollution. Included in the reports were qualitative and quantitative data on wastes discharged into the harbor.

With the exception of one ocean outfall, all Naval installations and ships' wastewaters do not have treatment before being discharged into Pearl Harbor. Corrective measures, however, are currently in progress. Construction of sewage treatment plants, extended aeration "package plants", the upgrading of primary to secondary plants, and the connection of existing sewer lines to county sewage treatment plants are some of the concrete actions undertaken by the Naval Facilities Engineering Command, Pacific Division, to abate water pollution. Table IX summarizes the dates and programs of construction for the numerous projects.

Plans for an industrial waste treatment plant have been received by the Navy, and a project number has been assigned for the construction of the plant in 1970.

An engineering firm is currently conducting a study on the ground seepage of oil into the storm drains which eventually empty into the harbor. The industrial waste treatment plant is designed to handle oil wastes.

TABLE IX

MILITARY PLANS FOR WASTE TREATMENT FACILITIES AT PEARL HARBOR

LOCATION	TYPE OF TREATMENT	AVERAGE DESIGN FLOW	METHOD OF EFFLUENT DISPOSAL	EXPANSION PLANNED	CONSTRUCTION PROJECT NO., FY
Fort Kam STP*	Step aeration Activated sludge	4.0 mgd	Ocean outfall sewer	Yes	P-010,1970
Capehart Hsng.**	Secondary	0.533 mgd	Ocean outfall sewer	Yes	C-3-66,1970
Iroquois Point	Activated sludge				
NAD West Loch**	Plant A--Extended aeration, "Pkg.Plant"	0.042 mgd	Three leaching pits	No	P-034,1970
	Plant B--Extended aeration, "Pkg.Plant"	6,000 gpd	One leaching pit	No	
Ford Island**	Extended aeration	298,500 gpd	Outfall sewer	No	P-114,1970
Waipio**	Extended aeration "Pkg. Plant"	3,300 gpd	Outfall sewer	No	P-115,1970
	Extended aeration "Pkg. Plant"	11,600 gpd	One leaching pit	No	P-115,1970
Industrial Waste	Acid-alkali wastes	20,000 gal/yr.	Fort Kam STP	No	P-116,1970
Treatment Fac.	Chromium wastes	12,000 gal/yr.	"		
Pearl Harbor	Cyanide wastes	2,800 gal/yr.	"		
	Oil wastes	325 gpm	"		

* Expansion to 7.5 mgd programmed under P-116, 1970.
** Proposed.

PLANS FOR DEVELOPMENT OF THE OYSTER RESOURCE IN PEARL HARBOR

The Division of Fish and Game, State of Hawaii, has assumed the major role in attempting to utilize the oyster resource in Pearl Harbor. In order to manage and maintain the resource for maximum sustained yield, one segment of their program calls for biological studies of the life history of the oyster. Spawning, growth, condition, and other phases of the oyster's life history have been studied or are being worked on at the present time.

Transplanting oysters and spat to other suitable growing areas in order to extend their distribution is also an on-going project. These attempts have not been highly successful because of poaching on Molokai and rough sea conditions and unsuitable bottom habitat in Hilo Bay, Hawaii.

Relaying oysters to commercial fish ponds for cleansing and fattening for local market is currently under study. Two ponds on Oahu and one on Molokai are being used in the pilot studies.

VII

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APPENDIX A

ORGANIZATION OF SURVEY

GENERAL

Prior to actual field work in Pearl Harbor, an intensive survey of available literature was conducted. Information gathered from this search formed the basis for establishing a sampling program that would provide necessary information to update various water quality parameters without duplicating past work. The field work was divided into several phases. These included monitoring major tributaries and waste discharges, sampling for water quality throughout the harbor, a bacteriological investigation of the oysters and oyster-rearing waters in West Loch, and a survey of silt deposition and benthic life.

TRIBUTARIES AND WASTE DISCHARGE SAMPLING PROGRAM

Five major tributaries entering Pearl Harbor were selected for sampling. They were: Halawa, Kaluauao, Waimalu, Waiawa, and Waikele Streams. USGS gauging stations are located on these perennial streams and are accessible to sampling. Water samples were collected using a plastic bucket and/or a weighted, check valved, cylindrical sampler.

Water samples from the tributaries were tested for temperature, pH, total and fecal coliforms, nitrogen, phosphorus, and suspended and setteable solids. Station locations are shown in figure A1 and have the prefix "TT".

Five major waste discharges were sampled for suspended and settleable solids, phosphorus, nitrogen, and total and fecal coliforms. These discharges consisted of raw sewage, primary treated sewage, and combined industrial/domestic wastes. All discharge directly into Pearl Harbor. The sampling stations shown in figure A1 have the prefix "SE".

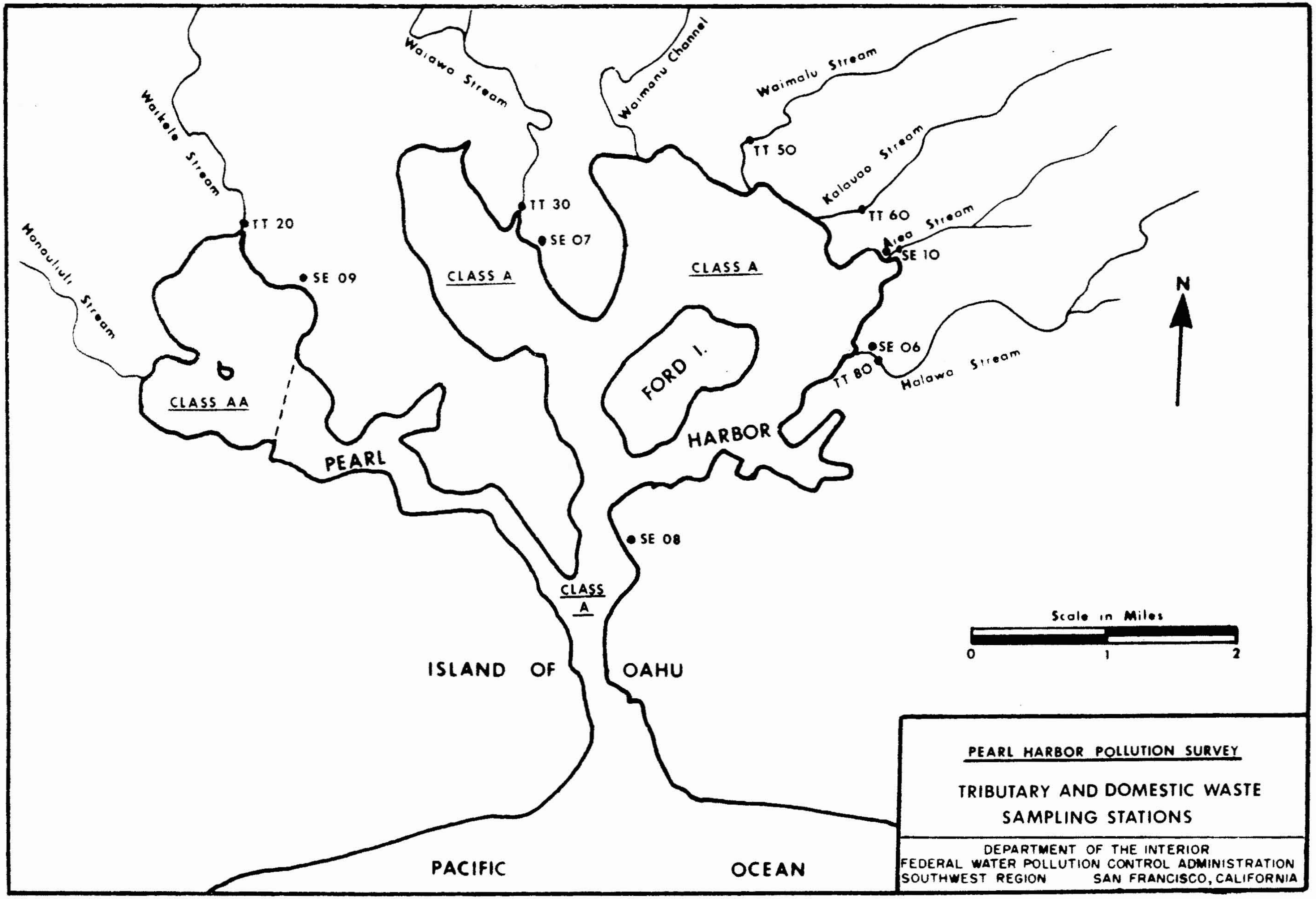
Waikele Stream
Waiawa Stream
Waimanu Channel
Waimalu Stream
Kalauao Stream
Aiea Stream
Halawa Stream
Honouliuli Stream
TT 20
TT 30
TT 50
TT 60
TT 80
SE 07
SE 09
SE 10
SE 06
SE 08
CLASS A
CLASS A
CLASS AA
CLASS A
FORD I.
PEARL
HARBOR
ISLAND OF
OAHU
PACIFIC
OCEAN
N
Scale in Miles
0
1
2
PEARL HARBOR POLLUTION SURVEY
TRIBUTARY AND DOMESTIC WASTE SAMPLING STATIONS
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHWEST REGION SAN FRANCISCO, CALIFORNIA

FIGURE A1

WATER QUALITY SAMPLING PROGRAM

Sixty-eight sampling stations were laid out on ranges arbitrarily established to provide a broad picture of conditions throughout the harbor. Ranges and stations were first located on a chart. Positive station location fixes with a sextant were then established in the field. In order to return to a given station with minimal effort, these fixes were associated with visually triangulated landmarks. The water quality ranges are shown in figure A2.

Water quality surveys in Pearl Harbor were conducted during the months of March, April, May, and June 1969. Parameters investigated during the surveys included: total coliforms, fecal coliforms, salinity, temperature, pH, dissolved oxygen, total phosphorus, Kjeldahl nitrogen, and nitrate-nitrite nitrogen.

Water sampling was conducted from an 18-foot twin outboard-powered skiff. Surface samples were taken by hand, and a 12-volt pumping system was used to acquire samples below the surface. The pump system was used only for acquiring water samples for chemical analyses.

Samples were preserved for chemical analyses with the addition of 1 milliliter (ml) concentrated sulfuric acid. The water quality stations in East Loch and the main channel carry the prefix "E", Middle Loch "M", West Loch "W", and special sampling stations (sewer outfalls) "SE". (figure A2)

BIOLOGICAL SAMPLING PROGRAM

The biological sampling program consisted of two phases. The first phase, a microbiological survey of the contamination of the oysters in West Loch, attempted to establish and confirm the excessive pollution which prohibits direct utilization of shellfish resources in this area. This was accomplished by sampling oysters and water from major beds and subjecting them to the multiple-tube analysis technique described in APHA (1962). Tests for determining the presence of *Salmonella* were also carried out on the oysters and oyster-rearing waters.

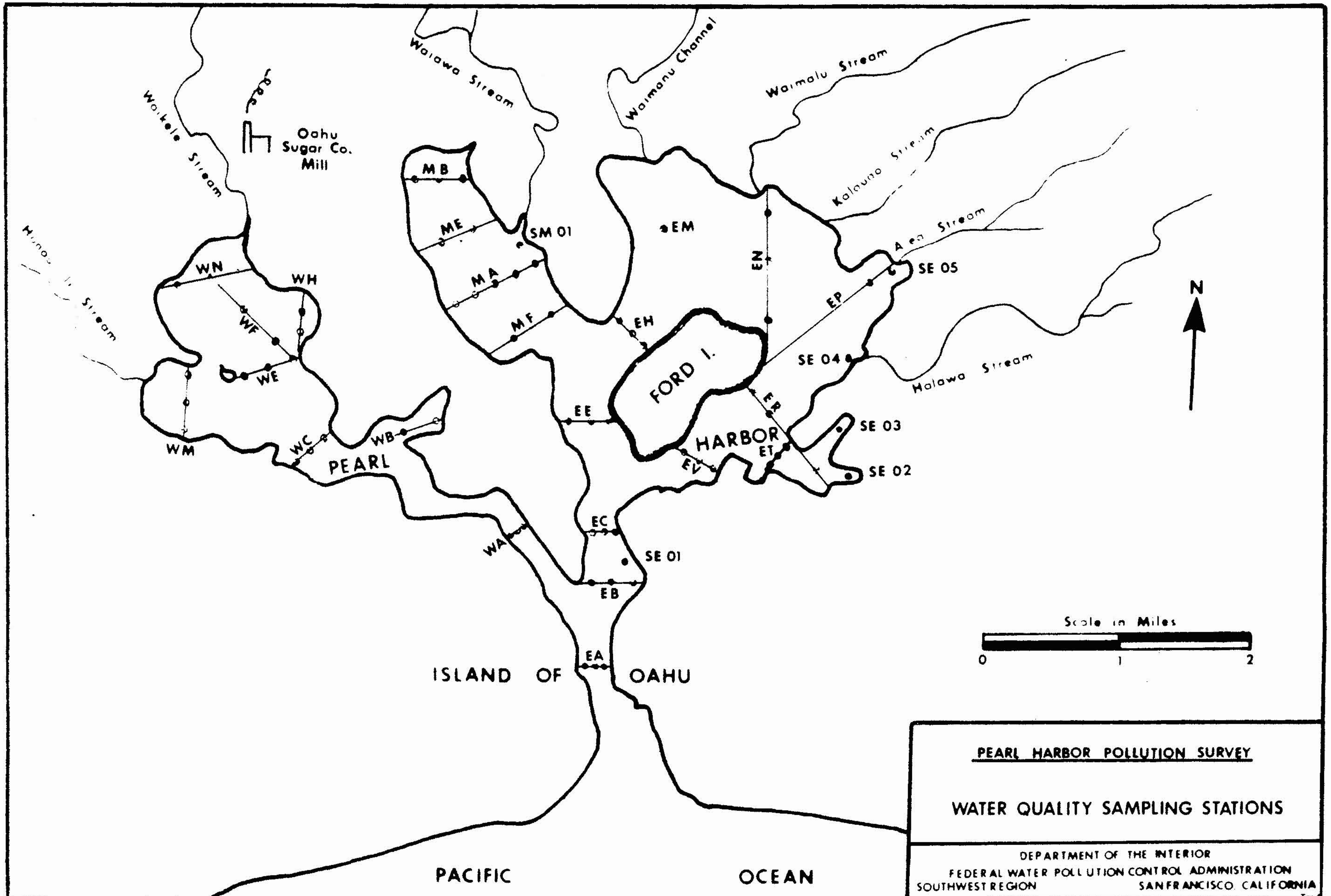
PEARL HARBOR POLLUTION SURVEY
WATER QUALITY SAMPLING STATIONS
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHWEST REGION
SAN FRANCISCO, CALIFORNIA
Scale in Miles
0
1
2
N
Waiawa Stream
Waimanu Channel
Waimalu Stream
Kalauao Stream
Aiea Stream
Halawa Stream
Waikele Stream
Oahu Sugar Co. Mill
Stream
MB
ME
MA
MF
SM 01
EM
EN
EH
EP
SE 05
SE 04
FORD I.
EE
ER
HARBOR
ET
EV
SE 03
SE 02
WN
WH
WF
WE
WM
WC
WB
PEARL
EC
SE 01
WA
EB
EA
ISLAND OF OAHU
PACIFIC OCEAN

FIGURE A2

The second phase was a survey of the silting and benthic conditions in the harbor and the possible effect of heavy silting on the oyster resource. Bottom samples were acquired using a Phleger corer and a Petersen dredge. Aerial photographs and field surveys of the oyster beds provided data on the effects of silting.

PUBLIC HEALTH REGULATIONS

Department of Health, State of Hawaii

Chapter 37-A

WATER QUALITY STANDARDS

Under and by virtue of the provisions of Sections 46-13 and 46-16, Revised Laws of Hawaii 1955, and all other applicable laws, Chapter 37-A of the Public Health Regulations, Department of Health, State of Hawaii, is hereby amended to read as follows:

Section 1. PURPOSE AND SCOPE

Pursuant to the authority granted by Section 46-16, Revised Laws of Hawaii 1955, the Director of Health of the State of Hawaii appointed a Master to divide the waters of the State into areas and to recommend to the Director standards of water quality for such water areas. Except as modified in this Chapter, the standards recommended by the Master are hereby adopted. The standards adopted, hereinafter set forth, shall be the standards of water quality for the purposes of Chapter 37, Public Health Regulations, Department of Health, State of Hawaii, and shall be enforced and administered as provided therein.

Section 2. DEFINITIONS

A. "Near shore waters" means all coastal waters lying within a defined reef area, all waters of a depth less than ten fathoms, or waters up to a distance of 1000 feet off-shore if there is no defined reef area and if the depth is greater than ten fathoms.

B. "Off-shore waters" means all coastal waters beyond the limits defined for "near shore waters."

C. "Coastal waters" includes "near shore waters," "off-shore waters" and those brackish waters, fresh waters and salt waters that are subject to the ebb and flow of the tide.

Section 3. CLASSIFICATION OF WATER USES

A. Classification of Coastal Water Uses

Coastal waters are classified in accordance with the uses to be protected in each class as follows:

1. *Class AA waters*

The uses to be protected in this class of waters are oceanographic research, propagation of shellfish and marine life, conservation of coral reefs and wilderness areas and aesthetic enjoyment.

It is the objective of this class of waters that they remain in as nearly their natural, pristine state as possible with an absolute minimum of pollution from any source. To the extent possible, the wilderness character of such areas shall be protected. No zones of mixing will be permitted in these waters.

The classification of any water area as Class AA shall not preclude other uses of such waters compatible with these objectives and in conformance with the standards applicable to them.

2. *Class A waters*

The uses to be protected in this class of waters are recreational, including fishing, swimming, bathing and other water-contact sports and aesthetic enjoyment.

It is the objective for this class of waters that their use for recreational purposes and aesthetic enjoyment not be limited in any way. Such waters shall be kept clean of any trash, solid materials or oils and shall not act as receiving waters for any effluent which has not received the best practicable treatment or control compatible with the standards established for this class.

3. *Class B waters*

The uses to be protected in this class of waters are small boat harbors, commercial, shipping and industrial, bait fishing and aesthetic enjoyment.

It is the objective for this class of waters that discharges of any pollutant be controlled to the maximum degree possible and that sewage and industrial effluents receive the best practicable treatment or control compatible for the standards established for this class.

The Class B designation shall apply only to a limited area next to boat docking facilities in bays and harbors. The rest of the water area in such bay or harbor shall be Class A unless given some other specific designation in Section 5.

B. Classification of Fresh Water Uses

Fresh waters are classified in accordance with the uses to be protected as follows:

1. *Class 1 waters*

The uses to be protected in this class of waters are drinking water supply and food processing.

It is the objective of this class of waters that they remain as nearly the natural state as possible with an absolute minimum of pollution from any source.

2. *Class 2 waters*

The uses to be protected in this class of waters are bathing, swimming, recreation, growth and propagation of fish and other aquatic life and agricultural and industrial water supply.

It is the objective for this class of waters that their use for recreational purposes, propagation of fish and other aquatic life and agricultural and industrial water supply not be limited in any way. Such waters shall be kept clean of trash, solid materials or oils and shall not act as receiving waters for any effluent which has not received the best practicable treatment compatible with the standards established for this class.

Section 4. ZONES OF MIXING

Zones of mixing for the assimilation of municipal, agricultural and industrial discharges which have received the best practicable treatment or control or such lesser degree of treatment or control as will provide for a water quality commensurate with the classified use of the waters outside the zone of mixing are recognized as necessary.

It is the objective of this limited zone to provide for a current realistic means of control over such discharges and at the same time achieve the highest attainable level of water quality.

Section 5. CLASSIFICATION AND ESTABLISHMENT OF WATER AREAS

The following classification of water uses shall apply to the following areas.

A. Coastal Water Areas

1. *Oahu*

(a) *Class AA waters*

Waimanalo Bay from Makapuu Point to the southerly boundary of Kaiona Beach Park and including the waters surrounding Manana and Kaohikaipu Islands.

That portion of Kaneohe Bay designated in blue on chart dated April 7, 1967, prepared by the Hawaii Institute of Marine Biology of the University of Hawaii and on file in the Department of Health, State of Hawaii.

Kahana Bay.

Waialua Bay, from Puaena Point to Kaiaka Point.

The near shore waters along Kaena Point for a distance of 3½ miles towards Mokuleia and 3½ miles towards Makua.

That portion of West Loch, Pearl Harbor, lying north of a tangent drawn from Nichols Point to Loch Point.

Hanauma Bay.

(b) *Class A Waters*

That portion of Waimanalo Bay not designated Class AA.

Kailua Bay, from Wailea Point to Mokapu Point.

The near shore waters between Mokapu Point and Pyramid Rock.

That portion of Kaneohe Bay, not designated Class AA or Class B.

The near shore waters between Makalii Point and Laie Point.

Laie Bay.

All coastal waters not included in any other class.

(c) *Class B waters*

Kaneohe Bay small boat harbor adjacent to Kaneohe Yacht Club.

Kaneohe Marine Corps Air Station small boat harbor and pier area.

Kewalo Basin.

Ala Wai Boat Harbor.

Pokai Bay small boat harbor.

Haleiwa small boat harbor.

Keehi Lagoon marina areas.

Heeia-Kea small boat harbor.

Campbell Estate Industrial Harbor.

Pearl Harbor — Middle Loch and East Loch and that portion of West Loch not classedas AA waters.

Honolulu Harbor.

2. *Kauai*

(a) *Class AA waters*

The near shore waters between Hikinoe Valley and Puu Poa Point, including Wainiha Bay and Hanalei Bay.

(b) *Class A waters*

All coastal waters of the island of Niihau.

All coastal waters of the island of Kauai not included in any other class.

(c) *Class B waters*

Wailua River small boat harbor.

Kukuiula Bay.

Hanapepe Bay small boat harbor.

Kikiaola Harbor.

Nawiliwili Bay.

Port Allen, Hanapepe Bay.

3. *Molokai*

(a) *Class AA waters*

The near shore waters between the westerly boundary of Haleolono Harbor and Laau Point.

The near shore waters between Laau Point and Ilio Point and from Ilio Point to Lamaola Head.

The near shore waters from Cape Halawa to the easterly boundary of Kaunakakai Harbor.

(b) *Class A waters*

Halawa Bay.

The near shore waters from the westerly boundary of Kaunakakai Harbor to the easterly boundary of Haleolono Harbor.

All coastal waters not included in any other class.

(c) *Class B waters*

Kaunakakai Harbor.

Haleolono Harbor.

4. *Lanai*

(a) *Class AA waters*

The near shore waters from the westerly boundary of Hulopoe Bay to the southerly boundary of Kaumalapau Harbor and from the northerly boundary of Kaumalapau Harbor to Kaiolohia Bay.

The near shore waters from Kamaika Point to the easterly boundary of Manele Bay.

(b) *Class A waters*

All coastal waters not included in any other class.

(c) *Class B waters*

Manele Bay.

Kaumalapau Harbor.

5. *Maui*

(a) *Class AA waters*

The near shore waters between Nakalele Point and Waihee Point.

The near shore waters between Huelo Point and Nanualele Point.

(b) *Class A waters*

All coastal waters not included in any other class.

(c) *Class B waters*

Maalaea small boat harbor.
Lahaina small boat harbor.
Kahului Bay.

6. *Hawaii*

(a) *Class AA waters*

The near shore waters from Ka Lae to Waiulaula Point excepting Kealakekua Bay, Honokahau Bay, Keauhou Bay and Kailua Bay.

(b) *Class A waters*

The near shore waters from the northern boundary of Kawaihae Harbor to the southern boundary of Mahukona Harbor.

The near shore waters from Kauilii Point to the westerly boundary of Hilo Harbor.

The near shore waters from the easterly boundary of Hilo Harbor to Ka Lae, excepting Honuapo Bay.

All coastal waters not included in any other class.

(c) *Class B waters*

Honuapo Bay.
Kealakekua Bay.
Keauhou Bay.
Kailua Bay.
Honokahau Bay..
Mahukona Harbor.
Hilo Harbor.
Kawaihae Harbor.

B. Fresh Water Areas

1. *Class 1 waters*

All sources of fresh surface water on all islands whether publicly or privately owned, used for domestic, culinary or food processing purposes.

2. *Class 2 waters*

All fresh water streams and rivers on all islands not included in Class 1.

Section 6. WATER QUALITY STANDARDS

A. Basic Standards Applicable to All Water Areas

All waters shall be free of substances attributable to discharges or wastes as follows:

1. Materials that will settle to form objectionable deposits;
2. Floating debris, oil, scum and other matter;
3. Substances producing objectionable color, odor, taste or turbidity;
4. Materials, including radionuclides, in concentrations or combinations which are toxic or which produce undesirable physiological responses in human, fish and other animal life and plants; and
5. Substances and conditions or combinations thereof in concentrations which produce undesirable aquatic life.

All waters shall also be free from soil particles resulting from erosion on land involved in earthwork, such as the construction of public works, highway, subdivisions, recreational, commercial, or industrial developments, or the cultivation and management of agricultural lands.

This standard shall be deemed met if it can be shown that the land on which the erosion occurred or is occurring is being managed in accordance with soil conservation practices acceptable to the Director, and that a comprehensive conservation program is being actively pursued, or that the discharge has received the best practicable treatment or control.

B. Specific Standards Applicable to Particular Water Areas

1. *Microbiological Requirements*	Applicable to:
The median coliform bacteria shall not exceed 70 per 100 ml, nor shall samples exceed 230 per 100 ml at any time.	Class AA
The median coliform bacteria shall not exceed 1,000 per 100 ml, nor shall more than 10% of the samples exceed 2,400 per 100 ml. Fecal coliform content shall not exceed an arithmetic average of 200/100 ml during any 30-day period nor shall more than 10% of the samples exceed 400/100 ml in the same time period. For such portion of Class 1 waters from which water is withdrawn for distribution for drinking water supply or food processing following simple chlorination, the fecal coliform content shall not exceed an arithmetic average of 20/100 ml during any calendar month.	Classes A, 1 and 2
Fecal coliform content shall not exceed an arithmetic average of 400/100 ml during any 30-day period nor shall more than 10% of the samples exceed 1000/100 ml in the same time period.	Class B
2. *pH — Units*	Applicable to:
Not more than ½ unit difference from natural conditions but not lower than 8.0 nor higher than 8.5 from other than natural causes. (Not lower than 7.0 for fresh tidal waters.)	Class AA
Not more than ½ unit difference from natural conditions but not lower than 7.0 nor higher than 8.5 from other than natural causes.	Classes A, B
Not less than 6.5 nor higher than 8.5.	Class 2
3. *Nutrient Materials*	Applicable to:
Total phosphorus, not greater than 0.020 mg/l.	Class AA
Total phosphorus, not greater than 0.025 mg/l.	Class A
Total phosphorus, not greater than 0.030 mg/l.	Class B
Total nitrogen, not greater than 0.10 mg/l.	Class AA
Total nitrogen, not greater than 0.15 mg/l.	Class A
Total nitrogen, not greater than 0.20 mg/l.	Class B
4. *Dissolved Oxygen (except from natural causes)*	Applicable to:
Not less than 6.0 mg/l.	Class AA
Not less than 5.0 mg/l.	Classes A, 2
Not less than 4.5 mg/l.	Class B

5. *Total Dissolved Solids, Salinity and Currents* No changes in channels, in basin geometry of the area, or in freshwater influx shall be made which would cause permanent changes in isohaline patterns of more than $\pm 10\%$ of naturally occurring variation or which would otherwise affect biological and sedimentological situation. Total dissolved solids shall not be below 28,000 mg/l from other than natural causes.	Applicable to: Class AA
6. *Temperature* Temperature of receiving waters shall not change more than 1.5°F from natural conditions.	Applicable to: Classes AA, A, B
7. *Turbidity* Secchi disc or secchi disc equivalent as "extinction coefficient" determinations shall not be altered from natural conditions more than 5% for Class AA waters, 10% for Class A waters or 20% for Class B waters.	Applicable to: Classes AA, A, B
8. *Radionuclides* The concentration of radioactivity in water shall not exceed 1/30th of the MPC_w values given for continuous occupational exposure in National Bureau of Standards Handbook No. 69. No radionuclide or mixture of radionuclides shall be present at concentrations greater than those specified by the U. S. Public Health Service, Publication No. 956, as revised in 1962, as acceptable for drinking water.	Applicable to: Classes AA, A, B, 1 and 2
The concentration of radioactive materials present in fresh, estuarine, and marine waters shall be less than those that would require restrictions on the use of organisms harvested from the area in order to meet the Radiation Protection Guides recommended by the Federal Radiation Council.	Classes AA, A, B and 2

These water quality criteria are based upon the best currently available data. It is possible that studies planned to be made in connection with the implementation program may prove them to be either inadequate or unattainable. For this reason, they will be subject to periodic review and, where necessary, to change. Any change will be made only after public hearing, held in compliance with the Hawaii Administrative Procedure Act and the Rules of Practice and Procedure of the Department of Health.

Section 7. ESTABLISHMENT OF ZONES OF MIXING

Upon the application of any person requesting that a portion of the water areas meeting the basic standards applicable to all waters be zoned for the assimilation of agricultural, municipal and industrial discharges, if the Director shall determine that such use will not unreasonably interfere with any actual use of the water areas for which it is classified, he shall then designate such portion as a zone of mixing.

The boundaries of each zone of mixing shall be fixed by the Director, taking into account protected uses of the body of water, existing natural conditions of the receiving water (i.e., depth, currents, location, etc.), character of the effluent, and the adequacy of the design of the outfall and diffuser system to achieve a maximum dispersion and assimilation of the treated or controlled waste with a minimum of undesirable or noticeable effect on the receiving water.

The application shall be made on forms furnished by the Director and shall contain the information required therein.

The establishment of a zone of mixing and the boundaries thereof shall be made only after hearing held by the Director on the island where the area is situated in accordance with the Hawaii Administrative Procedure Act and the Rules of Practice and Procedure of the Department of Health.

Section 8. TERMINATION OF ZONES OF MIXING

The Director, on his own motion, or on the application of any person, shall terminate the designation of a water area as a zone of mixing, if after a hearing, he shall determine that such water area meeting the basic standards applicable to all coastal waters will unreasonably interfere with any actual use of the water area. Such termination shall be made only after a hearing held by the Director on the island where the area is situated in accordance with the Hawaii Administrative Procedure Act and the Rules of Practice and Procedure of the Department of Health. Upon such termination, the standards of water quality applicable thereto shall be those established for the water as otherwise classified.

Section 9. EFFECTIVE DATE

This Chapter shall become effective thirty days after filing with the Lieutenant Governor.

Section 10. SEVERABILITY

If any provision of this Chapter, or its application to any person or circumstance, is held invalid, the application of such provision to other persons or circumstances, and the remainder of this Chapter, shall not be affected thereby.

I, Walter B. Quisenberry, M.D., Director of Health, hereby certify that the foregoing regulations were adopted by the Department of Health on the 26th day of December, 1967.

WALTER B. QUISENBERRY, M.D.
Director of Health

The foregoing regulations are hereby approved as to form this 9th day of January, 1968.

NOBUKI KAMIDA
Deputy Attorney General

BERT T. KOBAYASHI
Attorney General

The foregoing regulations are hereby approved this 26th day of January, 1968.

JOHN A. BURNS
Governor of Hawaii

PUBLIC HEALTH REGULATIONS

Department of Health, State of Hawaii

Chapter 37

WATER POLUTION CONTROL

Under and by virtue of the provisions of Sections 46-13 and 46-16, Revised Laws of Hawaii 1955, and all other applicable laws, Chapter 37 of the Public Health Regulations, Department of Health, State of Hawaii, relating to Water Pollution Control, is hereby amended to read as follows:

Section 1. DEFINITIONS

The following definitions shall apply in the interpretation and enforcement of this Chapter:

(a) "Water pollution" means

(1) Such contamination, or other alteration of the physical, chemical or biological properties, of any waters of the State, including change in temperature, taste, color, turbidity, or odor of the waters, or

(2) Such discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the State,

as will or is likely to create a nuisance or render such waters unreasonably harmful, detrimental or injurious to public health, safety or welfare, including harm, detriment or injury to public water supplies, fish and aquatic life and wildlife, recreational purposes, and agricultural, industrial, research and scientific uses of such waters.

(b) "Wastes" means waste materials of any kind, whether treated or not, and whether animal, mineral or vegetable, and whether liquid, gaseous, radioactive or solid, including sewage and agricultural and industrial wastes, which cause any waters of the State to be reduced in quality below the standards applicable to the area as set out in Chapter 37-A of the Public Health Regulations, Department of Health, State of Hawaii.

(c) "Treatment works" means the various devices used in the treatment of wastes including the necessary intercepting sewers, outfall sewers, or outlets, pumping, power and other equipment and their appurtenances.

(d) "Waters of the State" means all

(1) rivers, streams, canals,

(2) ponds, lakes, reservoirs,

(3) bays, harbors, channels,

(4) lagoons, and

(5) coastal and shore waters,

whether natural or artificial, which are situated within or bordering upon the State.

(e) "Person" means any individual, firm, association, organization, partnership, business trust, corporation, company, foundation or other institution or entity, or governmental agency.

(f) "Director" means the Director of Health or his duly authorized agent.

(g) "Master" means any person or persons appointed by the Director of Health to conduct investigations, to hold hearings, to report or make recommendations to the Director on matters of water pollution, the disposal of wastes and standards of water quality.

Section 2. STANDARDS OF WATER QUALITY

The Director may appoint a Master who shall divide the waters of the State into areas and who, after investigations and hearings conducted in accordance with the Rules of Practice and Procedure of the Department of Health, State of Hawaii, shall recommend standards of water quality applicable to such water areas. The standards of quality recommended by the Master shall be such as to protect the present and prospective best use of each water area. Consideration shall be given by the Master to the standards and requirements of other government agencies having legal responsibilities for water quality control.

Standards of water quality, or any modification thereof, shall become effective upon their adoption by the Director in accordance with the requirements of the Hawaii Administrative Procedure Act. Such standards shall remain in effect until amended or repealed by the Director.

Section 3. PERMITS REQUIRED

It shall be unlawful for any person to do any one of the following without a permit issued in accordance with the provisions of this Chapter:

(a) To discharge any wastes into any waters of the State so as to reduce the quality of the water below the standards of water quality adopted for such waters by Chapter 37-A;

(b) To construct, install, modify, alter, or operate any treatment works or part thereof or any extension or addition thereto;

(c) To construct or use any new outlet for the discharge of any wastes into the waters of the State.

Section 4. APPLICATION FOR PERMIT

Every application for a permit shall be made on forms furnished by the Director and shall be accompanied by a statement of the proposed activity, or by a complete and detailed plan, description and history of the proposed or existing treatment works or outlet for the discharge of any wastes into the waters of the State and of any proposed additions, modifications or alterations thereto. An application for the renewal of a permit need contain only such information as is necessary to reflect changes in the permitted activity or in the treatment works or outlet which have occurred since the original filing.

All persons responsible for existing treatment works or outlets which discharge wastes into any water areas for which standards of water quality have been adopted by the Director shall file, within sixty days after the date on which a notice of adoption of the standards of water quality for such area has been published, an application for a permit to continue to discharge such wastes.

Section 5. ISSUANCE OF PERMIT

Application for permits will be reviewed together with plans, descriptions and histories submitted by the person making such application and together with such additional information as may be requested by the Director to ascertain the effect or probable effect upon the standards of water quality established for the water area involved. No permit shall be issued by the Director unless the application and the supporting information clearly show that the issuance thereof is in the public interest and unless the application contains a schedule of implementing actions the applicant will follow in order to comply with such standards of water quality. No permit shall be denied unless the applicant has had an opportunity for a hearing by the Director.

The Director may issue a permit for any period not exceeding five years, or may renew a permit for any additional period not exceeding five years. Upon expiration of the period stated therein, the permit shall automatically terminate and no rights shall become vested in the permittee.

Each permit shall set forth the conditions under which it is issued and shall require the permittee to conform to a schedule of implementing actions designed to obtain compliance with the standards of water quality established for the water area involved. The conditions shall include, but shall not be limited to, a requirement that the permittee shall do effluent sampling and shall report the results of such sampling to the Director. Any permittee may apply for a change in the conditions of the permit. A statement of the reasons for requesting such change shall accompany the application.

Section 6. REVOCATION OF PERMIT

Each permit shall be subject to revocation, to modification or change by the Director if he shall determine that such action is in the public interest. In taking such action the Director shall consider operation records, investigations or other information regarding the treatment works, outlets or quality of the receiving waters. Such action shall be effected by giving written notice to the permittee.

The notice shall contain the reasons for the action.

No permit shall be revoked, modified, or changed unless the permittee has had an opportunity for a hearing by the Director.

Section 7. PENALTY

Any person who violates any provisions of this Chapter shall be guilty of a misdemeanor and upon conviction thereof shall be punished by a fine of not more than five hundred dollars ($500.00), or by imprisonment for not more than one (1) year, or by both such fine and imprisonment.

Section 8. SEVERABILITY

If any provision of this Chapter, or its application to any person or circumstance, is held invalid, the application of such provision to other persons or circumstances, and the remainder of this Chapter, shall not be affected thereby.

I, Walter B. Quisenberry, M.D., Director of Health, hereby certify that the foregoing regulations were adopted by the Department of Health on the 26th day of December, 1967.

WALTER B. QUISENBERRY, M.D.
Director of Health

The foregoing regulations are hereby approved as to form this 9th day of January, 1968.

NOBUKI KAMIDA
Deputy Attorney General

BERT T. KOBAYASHI
Attorney General

The foregoing regulations are hereby approved this 26th day of January, 1968.

JOHN A. BURNS
Governor of Hawaii

APPENDIX C

SUMMARY OF PAST STUDIES RELATING TO WATER QUALITY IN PEARL HARBOR

Much of the past work done in Pearl Harbor has been performed by engineering firms and has been concerned with the relation of surface currents and velocities to distribution of sewage from treatment plant outfalls. A small amount of water quality data is available from these sources.

The city and county of Honolulu's report, "Sewerage Master Plan for Waipahu," (1957), offers evidence based on limited BOD samples of deteriorating water quality during a five-year period from 1952 to 1957. Reflecting this trend are results from a station near the fish pond at Waikele Stream in West Loch (now being used as a dump by the city and county of Honolulu) which indicate that the BOD increased from 2.4 ppm to 46 ppm in the 5-year period. Because coliforms were run in the 1952 survey but not in the 1957 one, no trend can be established in this parameter. It was found that approximately 100 outfalls discharged into Pearl Harbor between Bishop Point and the Naval Supply Center. This finding relates to the closing of Pearl Harbor to fishing, swimming, and shell fishing because of increased pollution.

Several engineering surveys and studies have been undertaken by Austin Smith & Associates, et. al., (1960 - 1961), and contain information on surface and subsurface currents in Middle Loch. They found currents to run in a counter-clockwise direction in Middle Loch with an average speed of 300 feet per hour, compared to speeds of 1,200 feet per hour in the Pearl Harbor entrance channel. Tidal currents are not strong in West Loch and are dominated by other currents such as stream flow from Waiawa Stream, wind currents, particularly in the shallow area dredged to 22 feet, and other currents which appear to be caused by an underwater artificial shelf 13 feet high created in the upper half of West Loch by dredging. Some coliform samples were taken during the 1961 survey by Austin Smith & Associates and by Metcalf and Eddy in West Loch and East Loch.

Although few of the stations sampled for coliforms in past studies are located exactly on stations surveyed in this report, they are close enough to compare for purposes of establishing a trend of increased pollution in Pearl Harbor since 1952. Fifteen stations in Pearl Harbor could be compared to stations from either the 1952 survey or the 1961 survey.

A study by Au (1965) goes into detail on the mechanism of estuarine circulation and states that Pearl Harbor is a positive estuary. Au found salinities to range from less than 24 ppt to more than 34 ppt. With a welling of high salinity waters and entry of freshwater streams, salinities can change as much as 3 ppt in a distance of 10 feet. Salinities are fairly stable in the main channel, averaging 34.7 ppt. Lowest salinities were found in West Loch. Temperatures ranged from 23 degrees Celsius (C.) to 29 degrees C., with the higher readings found during the summer.

Isohalines (lines of equal or constant salinity) indicate a counter-clockwise circulation pattern throughout the harbor, with inflowing waters concentrating on the eastern banks and lower salinity outflowing waters along the western banks.

Au found that diatoms of the genera Chaetoceros and Skeletonema were the most prevalent, with frequent blooms of Asterionella, Rhizosolenia, and Thalassiothrix. Phytoplankton values were high, averaging 6 milligrams (mg) of chlorophyll per cubic meter (Chl-a/M^3). (Kaneohe Bay values average 0.9 mg. Chl-a/M^3.)

Low phosphate phosphorus (PO_4-P) values found by Au were thought to be the result of the rapid uptake of this nutrient by phytoplankton.

Current measurements by Au in the main channel at approximately Range EA (figure A2) gave evidence that the surface layer of water in Pearl Harbor is always moving seaward, regardless of the tidal flow, at an average speed of 0.7 knots. The interface between outflowing and inflowing waters is at a depth of at least 5 feet, and the inflowing lower waters reverse with the tide.

Under contract by the Hawaiian Electric Company, Larson (1968) completed a study of the distribution of isotherms (lines of equal or constant temperature) produced by the high temperature discharge from the Hawaiian Electric Company's Waiau Power

Plant, which is located in the northwest corner of East Loch. With ambient water temperatures around 23.30 degrees C., the warmer isotherms from the power plant extended out to about 1,100 feet from the outfall. At this distance, temperatures southeast of the outfall ranged up to 27.8 degrees C. On one day, condenser inlet temperatures were 25.8 degrees C., and outlet temperatures ranged from 33.6 degrees C. to 34.2 degrees C., (unit no. 5).

Under a contract with the Department of Land and Natural Resources, Sparks completed a study in 1962 of the oyster potential in Hawaii. A detailed survey of West Loch was made with the assistance of the Division of Fish and Game. Sparks estimated that 150,000 square yards of major oyster beds existed in West Loch with approximately 35,500,000 live oysters, Crassostrea virginica, present. He found that coliform density levels were high above all the beds in West Loch, with no samples meeting the 70 MPN level of acceptance. Levels of coliform in the oysters were higher than the surrounding water, showing the ability of the oysters to concentrate the bacteria. Coliform MPN/100 ml in the water ranged from 620 to 2,400,000, with a mean of 179,913. E. coliform concentrations ranged from 0 to 23,000 MPN/100 ml. In the oysters, MPN/100 ml ranged from 2,300 to 24,000,000 and E. coliform from 0 to 24,000,000 MPN/100 ml. It appeared unlikely that any oyster bed can be certified for direct consumption-type commercial harvesting in the foreseeable future. Histological examinations revealed all oysters in the samples taken were infected with an encysted larval tapeworm of the genus Tylocephalum.

Associated fauna were observed on the oyster beds, and many were identified. Sponges were extremely numerous and caused discomfort to an individual wading through the water because of silicenous sponge spicules penetrating the skin.

Despite heavy rainfalls, salinities did not fall below 12 ppt except in the area just off Matsuyama Pond, where a salinity of 4.5 ppt was found. In all the other cases in West Loch, the salinities varied from 12.5 ppt to 22 ppt and temperatures from 24 degrees C. to 27.2 degrees C.

As a follow-up of Sparks' study (1962), the Hawaiian Fish and Game Division conducted oyster depuration studies (Sakuda, 1964) on the contaminated oysters in West Loch. After four days of purification, the coliform levels in the oysters were considered to be acceptable for marketing.

Sakuda (1966, a) found the peak spawning season for Crassostrea virginica in West Loch to extend from March through October. He also found (1966, b) the condition of West Loch oysters generally to be of subcommercial quality. This was related to the effects of silting and subsequent interference with filtering and feeding by the oysters. Oyster meats were also color-tainted by the silt.

In 1966, the U. S. Navy investigated the total and fecal coliform densities in the West Loch oyster meats during the months of October and November. Their findings (unpublished data) show high concentrations of fecal contaminations, thus concurring with Sparks' report (1962). They also conducted a survey of the coliform densities found in the waters above the beds. The data reflect the resulting high coliform levels from heavy rains which occurred during the sampling period.

GPO 980-831

U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849